# Sequence IIIG LTMS Requirements (A Laboratory Based Severity Adjustment System)

**TEST METHOD PORTION**

 The following are the specific Sequence IIIG calibration test requirements.

 A. Reference Oils and Parameters

 The prediction error monitoring parameters are Percent Viscosity Increase (PVIS), Weighted Piston Deposits (WPD) and Average Camshaft plus Lifter Wear (ACLW). The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM Sequence III Surveillance Panel. The targets for the current reference oils for each parameter are presented below.

PERCENT VISCOSITY INCREASE

Unit of Measure: LN(PVIS)

PREDICTION ERROR MONITORING and SEVERITY ADJUSTMENT PARAMETER

|  |  |
| --- | --- |
| Reference Oil | Target |
| 434 | 4.7269 |
| 435 | 5.1838 |
| 438 | 4.5706 |

WEIGHTED PISTON DEPOSITS

Unit of Measure: Merits

PREDICTION ERROR MONITORING and SEVERITY ADJUSTMENT PARAMETER

|  |  |
| --- | --- |
| Reference Oil | Target |
| 434 | 4.80 |
| 435 | 3.59 |
| 438 | 3.20 |

AVERAGE CAMSHAFT plus LIFTER WEAR

Unit of Measure: LN(ACLW)

PREDICTION ERROR MONITORING and SEVERITY ADJUSTMENT PARAMETER

|  |  |
| --- | --- |
| Reference Oil | Target |
| 434 | 3.4657 |
| 435 | 3.4985 |
| 438 | 2.8814 |

 B. Acceptance Criteria

 1. New test labs. A new lab is defined as a test lab that has never previously achieved calibration.

a. A minimum of three (3) operationally valid reference and/or matrix tests with no level 3 ei alarms must be run on the first test stand in a new laboratory.

* Note that industry matrix runs may be included, as well as reference runs, at the discretion of the surveillance panel.

b. Following the necessary tests, check the status of the control charts and follow the prescribed actions.

2. Existing Test Lab

1. On a stand rotational basis, a laboratory shall begin a reference oil test no later than 125 days following the completion of the laboratory’s previous reference oil test or after no more than 25 test starts in the laboratory, whichever comes first. During periods following a failed stand calibration, invalid or aborted test, a grace period of an additional 15 days or additional starts equal to two (2) times the number of currently calibrated stands in the laboratory (as of EOT on failing stand), whichever comes first, shall be permitted from the completion date of the last acceptable calibration test. A laboratory has the option of moving to the next stand in the rotation to maintain lab calibration, independent of its action on the failing stand.
2. If not required to begin a reference oil test sooner, due to the above requirements, a stand shall begin a reference oil test no later than 365 days following the completion of the previous reference oil test on that stand.

c. New test stands in an existing lab, and test stands in an existing test lab that have not run an acceptable reference in the past two years, may calibrate with one test provided Level 1 limit requirement is met. Otherwise a second test is required for calibration.

d. For an existing test stand in an existing lab run one test

e. Following an operationally valid reference oil calibration test, check the status of the control charts and follow the prescribed actions.

 3. Reference Oil Assignment

 Once a test stand has been accepted into the system, the TMC will assign reference oils for continuing calibration according to the following reference oil mix:

* 100% of the scheduled calibration tests should be conducted on reference oils 434, 435 and 438 or subsequent approved reblends.

 4. Chart Status

 The following are the steps that must be taken in the case of exceeding chart limits. The steps are listed in order of priority, although charts should be studied simultaneously to determine the cause(s) of a problem. In the case of multiple alarms, contact the TMC for guidance. The laboratory always has the option of removing any stand from the system.

 a. Shewhart Chart of Prediction Error (ei) for **prediction error monitoring parameters only**

 • Level 3

– Immediately conduct one additional reference test in the stand that triggered the alarm. Do not update the control charts for the lab until the follow up reference test is completed and the ExI analysis, per Section 4.c (below), has been performed.

 • Level 2

– Reduce the number of tests allowed in the calibration period to 125 days or 20 tests.

 • Level 1

* + The level 1 limit applies in situations that have been pre-determined by the surveillance panel to have a potential impact on test results. These situations may include the introduction of new critical parts, fuel batches, reference oil reblends, or other test components. When these conditions have been met and a level 1 alarm is triggered, immediately conduct one additional reference test in the stand that triggered the alarm.
	+ The level 1 limit also applies to a stand in an existing test lab that has not run an acceptable reference in the past two years. The stand can calibrate with one test if the level 1 limits are not exceeded. Otherwise, immediately conduct another reference test in the stand. The Level 1 limit is used to judge the first reference test conducted in the stand unless otherwise dictated by the surveillance panel. Additional reference tests will be judged against the normal reference acceptance limits.

 b. Reference entity EWMA of Standardized Test Result (Zi) for **all parameters**

 • Level 2

* Immediately conduct one additional reference test either
	+ in the stand that triggered the alarm, or
	+ in the stand that is next due for calibration.
		- The stand that triggered the alarm is not calibrated for non-reference testing without further reference testing.

 • Level 1

* The level 1 limit applies to all reference tests that are control charted, even when other alarms have been triggered. Level 1 uses Zi to determine the laboratory severity adjustment (SA). Calculate the laboratory SA for each parameter as follows and confirm the calculation with the TMC:

SA = -Zi x sSA

where sSA =industry approved severity adjustment standard deviation

 c. Excessive influence (ExI) Analysis for **prediction error monitoring parameters only**

* The ExI analysis is performed anytime that a lab ei level 3 alarm is triggered. As prescribed in Section 4.a, Level 3, a follow up reference test is run. The following comparisons then determine whether the value of Yi is modified to limit its influence on LTMS. Yi+1 is the next completed reference in the laboratory after the level 3 alarm
1. If |Yi – Yi+1| ≤ ei level 3 limit, then Yi is equal to the value originally determined.
2. If Yi > Zi-1 and Yi-Yi+1 > ei level 3 limit, then let

Yi = ei level 3 limit + Zi-1.

1. If Yi ≤ Zi-1 and Yi-Yi+1 < -ei level 3 limit, then let

Yi = -ei level 3 limit + Zi-1.

1. If none of i), ii), or iii) is true, then Yi is equal to the value originally determined.

 Where: i = test that originally triggered level 3 alarm,

 i-1 = test prior to alarm trigger, and

 i+1 = test immediately following alarm trigger.

 Once the proper Yi value has been determined, update the charts. Confirm calculations with the TMC. The laboratory and the TMC maintain a record of the modification.

d. Industry EWMA of Standardized Test Result (Zi) for **all parameters**

 • Level 2

* + TMC informs the surveillance panel that the limit has been exceeded. The surveillance panel then investigates and pursues resolution of the alarm.

 • Level 1

* + The TMC investigates whether severity adjustments are adequately addressing the trend, investigates the possible causes, and communicates as appropriate with industry.

**TMC COMPENDIUM PORTION**

 The following are the specific Sequence IIIG calibration test requirements.

 A. Reference Oils and Parameters

 The prediction error monitoring parameters are Percent Viscosity Increase (PVIS), Weighted Piston Deposits (WPD and Average Camshaft plus Lifter Wear (ACLW). The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM Sequence III Surveillance Panel. The standard deviations for the current reference oils for each parameter are presented below.

PERCENT VISCOSITY INCREASE

Unit of Measure: LN(PVIS)

PREDICTION ERROR MONITORING and SEVERITY ADJUSTMENT PARAMETER

|  |  |
| --- | --- |
| Reference Oil | Standard Deviation |
| 434 | 0.3859 |
| 435 | 0.3096 |
| 438 | 0.1768 |

WEIGHTED PISTON DEPOSITS

Unit of Measure: Merits

PREDICTION ERROR MONITORING and SEVERITY ADJUSTMENT PARAMETER

|  |  |
| --- | --- |
| Reference Oil | Standard Deviation |
| 434 | 0.96 |
| 435 | 0.58 |
| 438 | 0.33 |

AVERAGE CAM plus LIFTER WEAR

Unit of Measure: LN(ACLW)

PREDICTION ERROR MONITORING and SEVERITY ADJUSTMENT PARAMETER

|  |  |
| --- | --- |
| Reference Oil | Standard Deviation |
| 434 | 0.1933 |
| 435 | 0.2342 |
| 438 | 0.2082 |

 B. Monitoring and Adjustment Parameters

 The constants used for the construction of the control charts for the Sequence IIIG, and the adjustment and monitoring chart limits, are shown below.

Laboratory Shewhart Limits for Prediction Error Monitoring Parameters

|  |
| --- |
| Shewhart Chart of Prediction Error ei = Yi – Zi-1 |
| Limit Type | PVIS | WPD | ACLW |
| Level 3 | 2.066 | 2.066 | Note 1 |
| Level 2 | 1.734 | 1.734 | Note 1 |
| Level 1 | 1.351 | 1.351 | Note 1 |

Laboratory EWMA Limits for Each Severity Adjustment Parameter

|  |
| --- |
| EWMA of Standardized Test Result Zi = λ(Yi) + (1 – λ)Zi-1 |
| Limit Type | λ | PVIS | WPD | ACLW |
| Level 2Upper Limit | 0.2 | 2.0 | 2.0 |  Note 1 |
| Level 2Lower Limit | 0.2 | -2.0 | -1.5 | Note 1 |
| Level 1 | 0.2 | 0 | 0 | 0 |

 Note 1 – Working Group unable to make recommendation

Severity Adjustment Standard Deviation for Each Severity Adjustment Parameter

|  |  |
| --- | --- |
| Severity Adjustment Parameter | Severity Adjustment Standard Deviation: sSA |
| PVIS | 0.2919 |
| WPD | 0.60 |
| ACLW | 0.1903 |

Industry EWMA Limits for Each Severity Adjustment Parameter

|  |
| --- |
| EWMA of Standardized Test Result Zi = λ(Yi) + (1 – λ)Zi-1 |
| Limit Type | Λ | Limit |
| Level 2Upper Limit | 0.2 | Note 1 |
| Level 2Lower Limit | 0.2 | Note 1 |
| Level 1 | 0.2 | Note 1 |

 Note 1 – Working Group unable to make recommendation