# Cummins ISB LTMS Requirements(A Laboratory Based Severity Adjustment System)

**TEST METHOD PORTION**

**9. Engine/Stand Calibration and Non-Reference Oil Tests**

NOTE 5—This section is addressed to those laboratories that choose to

utilize the services of the TMC2 in maintaining calibration of the test

stand.

9.1 *General*—Calibrate the test engine and the test stand by

conducting a test with a blind reference oil.2 Submit the results

to the TMC2 for determination of acceptance according to the

Lubricant Test Monitoring System (LTMS).

9.1.1 Because the Cummins ISB common rail engine is a

parent bore block and is not completely rebuilt before each test,

an engine is not referenced to a stand. The stand is calibrated

for use with different ISB common rail engines as supplied

from the CPD.4

9.2 *New Test Laboratory/Stand*—A new test laboratory is

defined as a laboratory that has never successfully calibrated a

test stand. The first test stand at a new laboratory requires three

successful calibration tests to establish its first calibration

period. All subsequent calibration periods on that stand or any

other stand within that laboratory require one successful

calibration test.

9.3 *Stand Calibration Period*:

9.3.1 The first two calibration periods on a new test stand

are carried out 12 months or 12 operationally valid nonreference

oil tests, whichever comes first, from the completion

of the last successful calibration test.

9.3.2 All subsequent calibration periods on a test stand are

18 months or 12 operationally valid non-reference oil tests,

whichever comes first, from the completion of the last successful

calibration test.

9.3.3 *Last Start Date*—A non-reference oil test may be

completed provided the warm-up is started prior to the expiration

of the calibration period.

9.4 *Stand Modification and Calibration Status*—

Modification of the test stand control systems or the conducting

of any non-standard test, or both, can invalidate the calibration

status. A non-standard test includes any test conducted under a

modified procedure, non-procedural hardware, controller setpoint

modifications, or a combination thereof. Contact the

TMC2 to determine if any such proposed modifications will

affect the calibration status.

9.5 *Test Numbering System*:

9.5.1 *General*—The test number has four parts, W-X-Y-Z:

W represents the test stand number, X represents the run

number for that stand (and has a XXX format), Y represents the

eight-digit serial number for that engine, and Z represents the

number of test hours completed by that engine block prior to

starting the test and has a format XXXX. The value for the

number of test hours on the engine, Z, does NOT include the

80 h break-in time (see 10.1) nor does it include time for

warm-up and cool-down run times. As an example, test number

64-002-57216596-0350 indicates stand number 64, test number

002 for that stand, engine serial number 57216596, and the

engine has 0350 test hours prior to starting this test on engine

block 57216596. Every test start (reference oil and nonreference

oil) increments X by one.

9.5.2 *Reference Oil Tests*—The sequential stand run number

remains unchanged for reruns of aborted, invalid, or unacceptable

calibration tests. However, follow the sequential stand run

number by a letter suffix (Afor the first rerun, B for the second,

and so forth).

9.5.3 *Non-Reference Oil Tests*—Do not add a letter suffix to

X for aborted or operationally invalid, non-reference oil tests.

9.6 *Reference Oil Test Acceptance*:

9.6.1 Reference oil test acceptance is determined in accordance

with the LTMS.2

A. Reference Oils and Parameters

The prediction error monitoring, severity adjustment, and reference period adjustment parameters are average cam shaft wear and average tappet weight loss. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM Cummins Surveillance Panel. The targets for the current reference oils for each parameter are presented below.

AVERAGE CAM SHAFT WEAR

Unit of Measure: *Micrometers*

PREDICTION ERROR MONITORING, SEVERITY ADJUSTMENT, AND REFERENCE INTERVAL ADJUSTMENT PARAMETER

|  |  |  |
| --- | --- | --- |
| Reference Oil | Mean | Standard Deviation |
| 831 | 42.5 | 5.0 |
| 831-1 | 42.5 | 5.0 |

AVERAGE TAPPET WEIGHT LOSS

Unit of Measure: *Milligrams*

PREDICTION ERROR MONITORING, SEVERITY ADJUSTMENT, AND REFERENCE INTERVAL ADJUSTMENT PARAMETER

|  |  |  |
| --- | --- | --- |
| Reference Oil | Mean | Standard Deviation |
| 831 | 97.2 | 14.8 |
| 831-1 | 97.2 | 14.8 |

B. Acceptance Criteria

1. New Test Labs

a. A minimum of three (3) operationally valid reference and/or matrix tests 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.

c. If two full length reference oil tests are declared operationally invalid during the attempt to calibrate a stand, then an increase in the reference interval per section 5.d may not be granted.

2. Existing Test Lab

a. 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.

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

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

d. If two full length reference oil tests are declared operationally invalid during the attempt to calibrate a stand, then an increase in the reference interval per section 5.d may not be granted.

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 831, and 831-1 or subsequent approved reblends.

4. Adjustment (Zi) and Monitoring (ei) Charts

In Section 1, the construction of the adjustment and monitoring charts used in the Lubricant Test Monitoring System are outlined. The constants used for the construction of the control charts for the Cummins ISB, 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 | Limit\* |
| Level 3 | 2.066 |
| Level 2 | 1.734 |
| Level 1 | 1.351 |

Laboratory EWMA Limits for Each Severity Adjustment Parameter

|  |  |  |  |
| --- | --- | --- | --- |
| EWMA of Standardized Test Result Zi = λ(Yi) + (1 – λ)Zi-1 | | | |
| Parameter | Limit Type | λ | Limit |
| Average Cam Shaft Wear | Level 2  Upper Limit | 0.2 | 1.5 |
| Average Cam Shaft Wear | Level 2  Lower Limit | 0.2 | -1.5 |
| Average Cam Shaft Wear | Level 1 | 0.2 | 0 |
| Average Tappet Weight Loss | Level 2  Upper Limit | 0.2 | 2.0 |
| Average Tappet Weight Loss | Level 2  Lower Limit | 0.2 | -1.5 |
| Average Tappet Weight Loss | Level 1 | 0.2 | 0 |

Laboratory Prediction Error and EWMA Reference Period Extension Limits for Each Reference Period Adjustment Parameter

|  |  |
| --- | --- |
| Limit Type | Limit |
| Ee | 1.05 |
| EZ | 0.66 |

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 2  Upper Limit | 0.2 | 0.860 |
| Level 2  Lower Limit | 0.2 | -0.860 |
| Level 1 | 0.2 | 0.653 |

5. 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 5.c (below), has been performed.

• Level 2

– Reduce the number of tests allowed in the calibration period in the stand that triggered the alarm to 9.6 valid non-reference oil 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.

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 5.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. Increase in the Number of Tests for the Stand Calibration Period

• The number of tests allowed in a stand calibration period, for existing stands only, may be increased if the previous test was an acceptable reference based upon the chart results for all prediction error monitoring parameters as follows:

* + If |ei| ≤ Ee, then the number of tests allowed for that calibration period may be increased by 2.4 valid non-reference oil tests, and the time between references may be increased by 2.4 months, or
  + If |ei| ≤ Ee and |Zi|≤ Ze, then the number of tests allowed for that calibration period may be increased by 4.8 valid non-reference oil tests, and the time between references may be increased by 4.8 months.

Confirm calculations with the TMC.

• If two full length reference oil tests are declared operationally invalid during the calibration sequence in the same stand, then the increase in calibration period will not be granted

e. 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.

9.7 *Reference Oil Accountability*:

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9.7.1 Laboratories shall provide a full accounting of the

identification and quantities of all reference oils used. With the

exception of the oil analyses required in 11.4, perform no

physical or chemical analyses of reference oils without written

permission from the TMC. In such an event, include the written

confirmation and the data generated in the reference oil test

report.

9.7.2 Retain used reference oil samples for 90 days from the

End of Test (EOT) date.

9.8 *Donated Reference Oil Test Programs*—The ASTM

D02.B0.02 Cummins Surveillance Panel is charged with maintaining

effective reference oil test severity and precision

monitoring. During times of new parts introductions, new or

re-blended reference oil additions, and procedural revisions, it

may be necessary to evaluate the possible effects on severity

and precision levels. The Surveillance Panel may choose to

conduct a program of donated reference oil tests in those

laboratories participating in the monitoring system, in order to

quantify the effect of a particular change on severity and

precision. Typically, the Surveillance Panel requests its panel

members to volunteer enough reference oil test results to create

a robust data set. Broad laboratory participation is needed to

provide a representative sampling of the industry. To ensure the

quality of the data obtained, donated tests are conducted on

calibrated test stands. The Surveillance Panel shall arrange an

appropriate number of donated tests and ensure completion of

the test program in a timely manner.

9.9 *Adjustments to Reference Oil Calibration Periods*:

9.9.1 *Procedural Deviations*—On occasions when a laboratory

becomes aware of a significant deviation from the test

method, such as might arise during an in-house review or a

TMC inspection, the laboratory and the TMC shall agree on an

appropriate course of action to remedy the deviation. This

action may include the shortening of existing reference oil

calibration periods.

9.9.2 *Parts and Fuel Shortages*—Under special circumstances,

such as industrywide parts or fuel shortages, the

Surveillance Panel may direct the TMC to extend the time

intervals between reference oil tests. These extensions shall not

exceed one regular calibration period.

9.9.3 *Reference Oil Test Data Flow*—To ensure continuous

severity and precision monitoring, calibration tests are conducted

periodically throughout the year. There may be occasions

when laboratories conduct a large portion of calibration

tests in a short period of time. This could result in an

unacceptably large time frame when very few calibration tests

are conducted. The TMC can shorten or extend calibration

periods as needed to provide a consistent flow of reference oil

test data. Adjustments to calibration periods are made such that

laboratories incur no net loss (or gain) in calibration status.

9.9.4 *Special Use of the Reference Oil Calibration System*—

The Surveillance Panel has the option to use the reference oil

system to evaluate changes that have potential impact on test

severity and precision. This option is only taken when a

program of donated tests is not feasible. The Surveillance

Panel and the TMC shall develop a detailed plan for the test

program. This plan requires all reference oil tests in the

program to be completed as close to the same time as possible,

so that no laboratory/stand calibration is left in an excessively

long pending status. In order to maintain the integrity of the

reference oil monitoring system, each reference oil test is

conducted so as to be interpretable for stand calibration. To

facilitate the required test scheduling, the Surveillance Panel

may direct the TMC to lengthen and shorten reference oil

calibration periods within laboratories such that the laboratories

incur no net loss (or gain

**TMC COMPENDIUM PORTION**

A. Reference Oils and Parameters

The prediction error monitoring, severity adjustment, and reference period adjustment parameters are average cam shaft wear and average tappet weight loss. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM *Cummins* Surveillance Panel. The standard deviations for the current reference oils for each parameter are presented below.

AVERAGE CAM SHAFT WEAR

Unit of Measure: *Micrometers*

PREDICTION ERROR MONITORING, SEVERITY ADJUSTMENT, AND REFERENCE INTERVAL ADJUSTMENT PARAMETER

|  |  |
| --- | --- |
| Reference Oil | Standard Deviation |
| 831 | 5.0 |
| 831-2 | 5.0 |

AVERAGE TAPPET WEIGHT LOSS

Unit of Measure: *Milligrams*

PREDICTION ERROR MONITORING, SEVERITY ADJUSTMENT, AND REFERENCE INTERVAL ADJUSTMENT PARAMETER

|  |  |
| --- | --- |
| Reference Oil | Standard Deviation |
| 831 | 14.8 |
| 831-1 | 14.8 |

B. Acceptance Criteria

4. Adjustment (Zi) and Monitoring (ei) Charts

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| Average Cam Shaft Wear | Level 1 | 0.2 | 0 |
| Average Tappet Weight Loss | Level 2  Upper Limit | 0.2 | 2.0 |
| Average Tappet Weight Loss | Level 2  Lower Limit | 0.2 | -1.5 |
| Average Tappet Weight Loss | Level 1 | 0.2 | 0 |

Laboratory Prediction Error and EWMA Reference Period Extension Limits for Each Reference Period Adjustment Parameter

|  |  |
| --- | --- |
| Limit Type | Limit |
| Ee | 0.5 |
| EZ | 0.5 |

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 2  Upper Limit | 0.2 | 0.860 |
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