# Sequence VID LTMS Requirements (A Stand-Engine Based Severity Adjustment System)

**TEST METHOD PORTION**

The following are the specific Sequence VID calibration test requirements.

A. Reference Oils and Parameters

The prediction error monitoring parameters are Fuel Economy Improvement at 16 hours (FEI1) and Fuel Economy Improvement at 100 hours (FEI2). The reference oils required for test stand-engine calibration are reference oils accepted by the ASTM Sequence VID Surveillance Panel. The targets for the current reference oils for each parameter are presented below.

FUEL ECONOMY IMPROVEMENT at 16 Hours

Unit of Measure: Percent

PREDICTION ERROR MONITORING PARAMETER

|  |  |
| --- | --- |
| Reference Oil | Target |
| 540 | 1.32 |
| 541 | 0.87 |
| 542 | 1.49 |

FUEL ECONOMY IMPROVEMENT at 100 Hours

Unit of Measure: Percent

PREDICTION ERROR MONITORING PARAMETER

|  |  |
| --- | --- |
| Reference Oil | Target |
| 540 | 1.04 |
| 541 | 0.71 |
| 542 | 0.80 |

B. Acceptance Criteria

1. New stand-engine combination. A new stand-engine combination is defined as a stand-engine combination that has never previously achieved calibrated status.

a. A minimum of three (3) operationally valid reference and/or matrix tests with no level three ei alarms (uninterrupted by nonreference oil tests) must be run on each new stand-engine combination.

* 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. The first (3) tests must be conducted on reference oils 540 (GF5A), 541 (GF5D) and 542 (GF5X). These oils will be assigned in random order by the TMC.

2. Existing Stand-Engine in a Lab

a. For an existing stand-engine run one test

b. 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:

* 40% of the scheduled calibration tests should be conducted on reference oil 540 (GF5A), or subsequent approved reblends.
* 20% of the scheduled calibration tests should be conducted on reference oil 541 (GF5D), or subsequent approved reblends.
* 40% of the scheduled calibration tests should be conducted on reference oil 542 (GF5X), 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 or engine 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-engine that triggered the alarm. Do not update the control charts until the follow up reference test is completed and the Excessive Influence (ExI) analysis, per Section 4.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 eight (8) full length tests or 1400 engine hours during the first three calibration intervals and six (6) full length tests or 1050 engine hours for subsequent calibration intervals.

• 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 previously calibrated stand-engine that has not run an acceptable reference in the past two years. The stand-engine can calibrate with one test if the level 1 limits are not exceeded. Otherwise, immediately conduct another reference test in the stand-engine. Level 1 limits are used to judge only the first valid reference in situations where it is determined to apply. All subsequent references in the stand-engine are judged against Level 2 and Level 3 limits unless otherwise indicated by the surveillance panel.

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

• Level 2

* Immediately conduct one additional reference test in the stand-engine that triggered the alarm

• 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 stand-engine severity adjustment (SA). Calculate the stand-engine 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 VID calibration test requirements.

A. Reference Oils and Parameters

The prediction error monitoring parameters are Fuel Economy Improvement at 16 hours (FEI1) and Fuel Economy Improvement at 100 hours (FEI2). The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM Sequence VID Surveillance Panel. The standard deviations for the current reference oils for each parameter are presented below.

FUEL ECONOMY IMPROVEMENT at 16 Hours

Unit of Measure: Percent

PREDICTION ERROR MONITORING PARAMETER

|  |  |
| --- | --- |
| Reference Oil | Standard Deviation |
| 540 | 0.12 |
| 541 | 0.12 |
| 542 | 0.12 |

FUEL ECONOMY IMPROVEMENT at 100 Hours

Unit of Measure: Percent

PREDICTION ERROR MONITORING PARAMETER

|  |  |
| --- | --- |
| Reference Oil | Standard Deviation |
| 540 | 0.14 |
| 541 | 0.14 |
| 542 | 0.14 |

B. Monitoring and Adjustment Parameters

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

Stand-Engine Shewhart Limits for Prediction Error Monitoring Parameters

|  |  |
| --- | --- |
| FUEL ECONOMY IMPROVEMENT at 16 Hours | |
| Shewhart Chart of Prediction Error ei = Yi – Zi-1 | |
| Limit Type | Limit |
| Level 3 | 2.126 |
| Level 2 | 1.784 |
| Level 1 | 1.390 |

|  |  |
| --- | --- |
| FUEL ECONOMY IMPROVEMENT at 100 Hours | |
| Shewhart Chart of Prediction Error ei = Yi – Zi-1 | |
| Limit Type | Limit |
| Level 3 | 2.126 |
| Level 2 | 1.784 |
| Level 1 | 1.390 |

Stand-Engine EWMA Limits for Each Severity Adjustment Parameter

|  |  |  |
| --- | --- | --- |
| FUEL ECONOMY IMPROVEMENT at 16 Hours | | |
| EWMA of Standardized Test Result Zi = λ(Yi) + (1 – λ)Zi-1 | | |
| Limit Type | λ | Limit |
| Level 2  Upper Limit | 0.3 | 2.5 |
| Level 2  Lower Limit | 0.3 | -2.5 |
| Level 1 | 0.3 | 0 |

|  |  |  |
| --- | --- | --- |
| FUEL ECONOMY IMPROVEMENT at 100 Hours | | |
| EWMA of Standardized Test Result Zi = λ(Yi) + (1 – λ)Zi-1 | | |
| Limit Type | λ | Limit |
| Level 2  Upper Limit | 0.3 | 2.5 |
| Level 2  Lower Limit | 0.3 | -2.5 |
| Level 1 | 0.3 | 0 |

Stand-Engine Severity Adjustment Standard Deviation for Each Severity Adjustment Parameter

|  |  |
| --- | --- |
| Parameter | sSA |
| FUEL ECONOMY IMPROVEMENT at 16 Hours | 0.12 |
| FUEL ECONOMY IMPROVEMENT at 100 Hours | 0.14 |

Industry EWMA Limits for Each Severity Adjustment Parameter

|  |  |  |
| --- | --- | --- |
| FUEL ECONOMY IMPROVEMENT at 16 Hours | | |
| EWMA of Standardized Test Result Zi = λ(Yi) + (1 – λ)Zi-1 | | |
| Limit Type | λ | Limit |
| Level 2  Upper Limit | 0.2 | TBD by SP Input |
| Level 2  Lower Limit | 0.2 | TBD by SP Input |
| Level 1 | 0.2 | TBD |

|  |  |  |
| --- | --- | --- |
| FUEL ECONOMY IMPROVEMENT at 100 Hours | | |
| EWMA of Standardized Test Result Zi = λ(Yi) + (1 – λ)Zi-1 | | |
| Limit Type | λ | Limit |
| Level 2  Upper Limit | 0.2 | TBD by SP Input |
| Level 2  Lower Limit | 0.2 | TBD by SP Input |
| Level 1 | 0.2 | TBD |