

6. Sequence IIIH LTMS Requirements

The following are the specific IIIH calibration test requirements.

A. Reference Oils and Critical Performance Criteria

The critical performance criteria are Percent Viscosity Increase (PVIS), and Weighted Piston Deposits (WPD). The reference oils required for test stand and test laboratory referencing are reference oils accepted by the ASTM Sequence III Surveillance Panel. The means and standard deviations for the current reference oils for each critical performance criterion are presented below.

Percent Viscosity Increase (PVIS)

Unit of Measure: ln(PVIS)

Reference Oil	Mean	Standard Deviation
434-2	4.7191	0.4310
434-3	5.7602	0.6598
436	3.3289	0.3138
438-1	3.9754	0.9558

Weighted Piston Deposits

Unit of Measure: Merits

Reference Oil	Mean	Standard Deviation
434-2	4.16	0.70
434-3	4.16	0.70
436	4.63	0.28
438-1	3.66	0.43

B. Acceptance Criteria

1. New Test Stands

- A minimum of two (2) operationally valid calibration tests and/or matrix tests, with no Level 3 e_i or level 2 Z_i alarms after the second operationally valid test must be conducted in a new stand on any approved reference oils.
- Note that industry matrix runs may be included, as well as reference runs, at the discretion of the surveillance panel.
- Following the necessary tests, check the status of the control charts and follow the prescribed actions.

2. Existing Test Stands

- The stand must have previously been accepted into the system by meeting the LTMS requirements.
- Existing test stands that have run an acceptable reference in the past 18 months may calibrate with 1 test.
- Following the necessary tests, check the status of the control charts and follow the prescribed actions.

3. Reference Oil Assignment

Once test stands have been accepted into the system, the TMC will assign reference oils for continuing calibration according to the reference oil mix:

- Scheduled calibration tests should be conducted on reference oils 436, 434-2, and 438-1 or subsequent approved reblends in equal proportion with random assignment.

4. Control Charts

In Section 1, the construction of the control charts that constitute the Lubricant Test Monitoring System is outlined. For the IIIH, $Z_0 = \text{Mean } Y_i$ of first two operationally valid tests in the stand. The constants used for the construction of the control charts for the IIIH, and the response necessary in the case of control chart limit alarms, are depicted below. Note that control charting all parameters is required.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA Chart		Stand Prediction Error	
		Severity		Severity	
Chart Level	Limit Type	Lambda	Alarm	Limit Type	Limit
Stand	Level 1	0.3	0.000	Level 1	N/A
	Level 2		±1.800	Level 2	±1.734
				Level 3	±2.066
Industry	Level 1	0.2	±0.775	--	--
	Level 2		±0.859	--	--

The following are the steps that must be taken in the case of exceeding control 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.

- Exceed Stand chart of Prediction Error (e_i)

Level 3:

- Immediately conduct one additional reference test in the stand that triggered the alarm. Do not update the control charts until the follow up reference test is completed and Excessive Influence (refer to Section 1.A.5) has been performed.

Level 2:

- The Level 2 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 2 alarm is triggered, immediately conduct one additional reference test in the stand that triggered the alarm.

- Exceed Stand EWMA of Standardized Test Result (Z_i)

Level 2:

- Conduct one additional reference test in the stand that triggered the alarm. The stand that triggered the alarm is not qualified for non-reference tests until the Level 2 alarm is cleared.
- In instances where surveillance panel has deemed that industry-wide circumstances are impacting the Level 2 alarm, the TMC may be asked to review stand calibration status in accordance with the surveillance panel's findings.

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 Z_i to determine the stand severity adjustment (SA). Calculate the stand SA as follows and confirm the calculation with the TMC:

Percent Viscosity Increase (ln(PVIS)): $SA = (-Z_i) \times (0.4641)$

Weighted Piston Deposits (WPD): $SA = (-Z_i) \times (0.47)$

- Exceed Industry EWMA of Standardized Test Result (Z_i)

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.

7. Sequence IIIHA LTMS Requirements

The following are the specific IIIHA calibration test requirements.

A. Reference Oils and Critical Performance Criteria

The critical parameter is MRV Apparent Viscosity. The reference oils required for test stand and test laboratory referencing are reference oils accepted by the ASTM Sequence III Surveillance Panel. The means and standard deviations for the current reference oils for each critical performance criterion are presented below.

MRV Viscosity
Unit of Measure: $\ln(\text{MRV})$

Reference Oil	Mean	Standard Deviation
434-2	11.1107	0.5220
434-3 ^A	---	---
436	9.7854	0.2423
438-1	9.8189	0.9132

^A For oil 434-3, use Sequence IIIH PVIS Y_i value as MRV Y_i value

B. Acceptance Criteria

1. New Test Stands

- Stand must be calibrated according to Sequence IIIH requirements. A Sequence IIIHA test must be conducted as part of each Sequence IIIH test.
- A minimum of two (2) operationally valid calibration tests and/or matrix tests, with no Level 3 e_i or level 2 Z_i alarms after the second operationally valid test must be conducted in a new stand on any approved reference oils.
- Note that industry matrix runs may be included, as well as reference runs, at the discretion of the surveillance panel.
- Following the necessary tests, check the status of the control charts and follow the prescribed actions.

2. Existing Test Stands

- Stand must be calibrated according to Sequence IIIH requirements. A Sequence IIIHA test must be conducted as part of each Sequence IIIH test.

- 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 e_i Level 1 limits are not exceeded. Otherwise a second test is required for calibration.
- Following the necessary tests, check the status of the control charts and follow the prescribed actions.

3. Reference Oil Assignment

Once test stands have been accepted into the system, the TMC will assign reference oils for continuing calibration according to the reference oil mix:

- Scheduled calibration tests should be conducted on reference oils 436, 434-2, and 438-1 or subsequent approved reblends in equal proportion with random assignment.

4. Control Charts

In Section 1, the construction of the control charts that constitute the Lubricant Test Monitoring System is outlined. For the IIIHA, $Z_0 = \text{Mean } Y_i$ of first two operationally valid tests in the stand. The constants used for the construction of the control charts for the IIIHA, and the response necessary in the case of control chart limit alarms, are depicted below. Note that control charting all parameters is required.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA Chart		Stand Prediction Error	
		Severity		Severity	
Chart Level	Limit Type	Lambda	Alarm	Limit Type	Limit
Stand	Level 1	0.3	0.000	Level 1	N/A
	Level 2		± 1.800	Level 2	± 1.734
				Level 3	± 2.066
Industry	Level 1	0.2	± 0.775	--	--
	Level 2		± 0.859	--	--

The following are the steps that must be taken in the case of exceeding control 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.

- Exceed Stand chart of Prediction Error (e_i)

Level 3:

- Immediately conduct one additional reference test in the stand that triggered the alarm. Do not update the control charts until the follow up reference test is completed and Excessive Influence (refer to Section 1.A.5) has been performed.

Level 2:

- The Level 2 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 2 alarm is triggered, immediately conduct one additional reference test in the stand that triggered the alarm.

- Exceed Stand EWMA of Standardized Test Result (Z_i)

Level 2:

- Immediately conduct one additional reference test in the stand that triggered the alarm. The stand that triggered the alarm is not qualified for non-reference tests until the Level 2 alarm is cleared.
- In instances where surveillance panel has deemed that industry-wide circumstances are impacting the Level 2 alarm, the TMC may be asked to review stand calibration status in accordance with the surveillance panel's findings.

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 Z_i to determine the stand severity adjustment (SA). Calculate the stand SA as follows and confirm the calculation with the TMC:

$$\text{MRV Apparent Viscosity (ln(MRV)): SA} = (-Z_i) \times (0.4725)$$

- Exceed Industry EWMA of Standardized Test Result (Z_i)

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.

8. Sequence IIIHB LTMS Requirements

The following are the specific IIIHB calibration test requirements.

A. Reference Oils and Critical Performance Criteria

The critical parameter is Phosphorous Retention. The reference oils required for test stand and test laboratory referencing are reference oils accepted by the ASTM Sequence III Surveillance Panel. The means and standard deviations for the current reference oils for each critical performance criterion are presented below.

PHOSPHOROUS RETENTION
Unit of Measure: Percent

Reference Oil	Mean	Standard Deviation
434-2	79.95	1.58
434-3	79.95	1.58
436	94.15	2.02
438-1	78.92	1.54

B. Acceptance Criteria

1. New Test Stands

- Stand must be calibrated according to Sequence IIIH requirements. A Sequence IIIHB test must be conducted as part of each Sequence IIIH test.
- A minimum of two (2) operationally valid calibration tests and/or matrix tests, with no Level 3 e_i or level 2 Z_i alarms after the second operationally valid test must be conducted in a new stand on any approved reference oils.
- Note that industry matrix runs may be included, as well as reference runs, at the discretion of the surveillance panel.
- Following the necessary tests, check the status of the control charts and follow the prescribed actions.

2. Existing Test Stands

- Stand must be calibrated according to Sequence IIIH requirements. A Sequence IIIHB test must be conducted as part of each Sequence IIIH test.
- 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 e_i Level 1 limits are not exceeded. Otherwise a second test is required for calibration.
- Following the necessary tests, check the status of the control charts and follow the prescribed actions.

3. Reference Oil Assignment

Once test stands have been accepted into the system, the TMC will assign reference oils for continuing calibration according to the reference oil mix:

- Scheduled calibration tests should be conducted on reference oils 436, 434-2, and 438-1 or subsequent approved reblends in equal proportion with random assignment.

4. Control Charts

In Section 1, the construction of the control charts that constitute the Lubricant Test Monitoring System is outlined. For the IIIHB, $Z_0 = \text{Mean } Y_i$ of first two operationally valid tests in the stand. The constants used for the construction of the control charts for the IIIHB, and the response necessary in the case of control chart limit alarms, are depicted below. Note that control charting all parameters is required.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA Chart		Stand Prediction Error	
		Severity		Severity	
Chart Level	Limit Type	Lambda	Alarm	Limit Type	Limit
Stand	Level 1	0.3	0.000	Level 1	N/A
	Level 2		± 1.800	Level 2	± 1.734
				Level 3	± 2.066
Industry	Level 1	0.2	± 0.775	--	--
	Level 2		± 0.859	--	--

The following are the steps that must be taken in the case of exceeding control 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.

- Exceed Stand chart of Prediction Error (e_i)

Level 3:

- Immediately conduct one additional reference test in the stand that triggered the alarm. Do not update the control charts until the follow up reference test is completed and Excessive Influence (refer to Section 1.A.5) has been performed.

Level 2:

- The Level 2 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 2 alarm is triggered, immediately conduct one additional reference test in the stand that triggered the alarm.

- Exceed Stand EWMA of Standardized Test Result (Z_i)

Level 2:

- Immediately conduct one additional reference test in the stand that triggered the alarm. The stand that triggered the alarm is not qualified for non-reference tests until the Level 2 alarm is cleared.
- In instances where surveillance panel has deemed that industry-wide circumstances are impacting the Level 2 alarm, the TMC may be asked to review stand calibration status in accordance with the surveillance panel's findings.

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 Z_i to determine the stand severity adjustment (SA). Calculate the stand SA as follows and confirm the calculation with the TMC:

$$\text{Phosphorous Retention: SA} = (-Z_i) \times (1.53)$$

- Exceed Industry EWMA of Standardized Test Result (Z_i)

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.

10. Sequence IVB LTMS Requirements

The following are the specific Sequence IVB calibration test requirements.

A. Reference Oils and Critical Performance Criteria

The critical parameters are Average Volume Loss Intake Bucket Lifter (AVLI) and Iron at End of Test (FeWMEOT). The reference oils required for test stand and test laboratory referencing are reference oils accepted by the ASTM Sequence IVB Surveillance Panel. The means and standard deviations for the current reference oils for each critical performance criterion are presented below.

Average Volume Loss Intake Bucket Lifter
Unit of Measure: sqrt(AVLI)

Reference Oil	Mean	Standard Deviation
300	1.3931	0.2230
1011	1.2538	0.1932
1012	1.1543	0.1847

End of Test Iron
Unit of Measure: ln(FeWMEOT)

Reference Oil	Mean	Standard Deviation
300	5.2645	0.3842
1011	5.0266	0.3508
1012	4.8344	0.3747

A. Acceptance Criteria

1. New Test Stands

- A minimum of two (2) operationally valid calibration tests and/or matrix tests, with no Level 3 e_i or level 2 Z_i alarms after the second operationally valid test must be conducted in a new stand on any approved reference oils.
- Note that industry matrix runs may be included, as well as reference runs, at the discretion of the surveillance panel.
- Following the necessary tests, check the status of the control charts and follow the prescribed actions.

2. Existing Test Stands

- Previously calibrated test stands that have not run an acceptable reference test for two reference periods, may calibrate with one test provided e_i Level 1 limits are not exceeded. Otherwise a second test is required for calibration.
- Following the necessary tests, check the status of the control charts and follow the prescribed actions.

3. Reference Oil Assignment

Once test stands have been accepted into the system, the TMC will assign reference oils for continuing calibration according to the reference oil mix:

- Scheduled calibration tests should be conducted on reference oils 300, 1011, and 1012 or subsequent approved reblends in equal proportion with random assignment.

4. Control Charts

In Section 1, the construction of the control charts that constitute the Lubricant Test Monitoring System is outlined. For the Sequence IVB, $Z_0 = \text{Mean } Y_i$ of first two operationally valid tests in the stand. The constants used for the construction of the control charts for the Sequence IVB, and the response necessary in the case of control chart limit alarms, are depicted below. Note that control charting all parameters is required.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA Chart		Stand Prediction Error	
		Severity		Severity	
Chart Level	Limit Type	Lambda	Alarm	Limit Type	Limit
Stand (AVLI)	Level 1	0.3	0.000	Level 1	± 1.351
	Level 2		± 1.800	Level 2	± 1.734
				Level 3	± 2.066
Stand (FeWMEOT)	Level 1	0.2	0.000	Level 1	± 1.351
	Level 2		± 1.800	Level 2	± 1.734
				Level 3	± 2.066
Industry	Level 1	0.2	± 0.775	--	--
	Level 2		± 0.859	--	--

The following are the steps that must be taken in the case of exceeding control 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.

- Exceed Stand chart of Prediction Error (e_i)

Level 3:

- Immediately conduct one additional reference test in the stand that triggered the alarm. Do not update the control charts until the follow up reference test is completed and Excessive Influence (refer to Section 1.A.5) has been performed.

Level 2:

- The Level 2 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 rebends, or other test components. When these conditions have been met and a Level 2 alarm is triggered, immediately conduct one additional reference test in the stand that triggered the alarm.

- Exceed Stand EWMA of Standardized Test Result (Z_i)

Level 2:

- Immediately conduct one additional reference test in the stand that triggered the alarm. The stand that triggered the alarm is not qualified for non-reference tests until the Level 2 alarm is cleared.
- In instances where surveillance panel has deemed that industry-wide circumstances are impacting the Level 2 alarm, the TMC may be asked to review stand calibration status in accordance with the surveillance panel's findings.

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 Z_i to determine the stand severity adjustment (SA). Calculate the stand SA as follows and confirm the calculation with the TMC:

$$\begin{aligned} \text{Average Volume loss Intake (sqrt(AVLI))}: SA &= (-Z_i) \times (0.2003) \\ \text{End of Test Iron (ln(FEWMEOT))}: SA &= (-Z_i) \times (0.3688) \end{aligned}$$

- Exceed Industry EWMA of Standardized Test Result (Z_i)

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:

- TMC informs the surveillance panel that the limit has been exceeded. The surveillance panel then investigates and pursues resolution of the alarm.
- The TMC investigates whether severity adjustments are adequately addressing the trend, investigates the possible causes, and communicates as appropriate with industry.

Sequence IIIH Reference Oil Targets							
Oil	n	Effective Dates		Percent Viscosity Increase		Weighted Piston Deposits	
		From ¹	To ²	\bar{X}	s	\bar{X}	s
434-2 ³	10	07-01-15	***	4.7191	0.4310	4.16	0.70
434-3	10	07-01-15	11-12-18	4.7191	0.4310	4.16	0.70
434-3	11	11-13-18	***	5.7602	0.6598	4.16	0.70
436 ³	9	07-01-15	***	3.3289	0.3138	4.63	0.28
438 ³	9	07-01-15	***	3.9754	0.9558	3.66	0.43

- 1 Effective for all tests completed on or after this date
- 2 *** = Currently in effect
- 3 Targets based on precision matrix analysis

Sequence IIIHA Reference Oil Targets					
Oil	n	Effective Dates		MRV Viscosity	
		From ¹	To ²	\bar{X}	s
434-2 ³	10	07-01-15	***	11.1107	0.5220
434-3	10	07-01-15	11-12-18	11.1107	0.5220
434-3 ⁴		11-13-18	***		
436 ³	9	07-01-15	***	9.7854	0.2423
438 ³	9	04-01-15	***	9.8189	0.9132

- 1 Effective for all tests completed on or after this date
- 2 *** = Currently in effect
- 3 Targets based on precision matrix analysis
- 4 For oil 434-3 completed after 11-12-18, use Sequence IIIH PVIS Yi value as MRV Yi value

Sequence IIIHB Reference Oil Targets					
Oil	n	Effective Dates		Phosphorus Retention %	
		From ¹	To ²	\bar{X}	s
434-2 ³	10	07-01-15	***	79.95	1.58
434-3	10	07-01-15	***	79.95	1.58
436 ³	9	07-01-15	***	94.15	2.02
438 ³	9	04-01-15	***	78.92	1.54

- 1 Effective for all tests completed on or after this date
- 2 *** = Currently in effect
- 3 Targets based on precision matrix analysis

Sequence IVB Oil Targets							
Oil	n	Effective Dates		AVLI		FeWMEOT	
		From ¹	To ²	\bar{X}	s	\bar{X}	s
300	9	10-27-17	***	1.3931	0.2230	5.2645	0.3842
1011	9	10-27-17	***	1.2538	0.1932	5.0266	0.3508
1012	10	10-27-17	***	1.1543	0.1847	4.8344	0.3747

1 Effective for all tests completed on or after this date.

2 *** = currently in effect.