

8. Sequence IX LTMS Requirements

The following are the specific Sequence IX calibration test requirements.

A. Reference Oils and Critical Performance Criteria

The critical performance criteria is Average Number of Preignitions (AVPIE). Additionally, an upper limit is set on Maximum Pre-ignition events. The reference oils required for test stand and test laboratory referencing are reference oils accepted by the ASTM Sequence IX Surveillance Panel. The means and standard deviations for the current reference oils for each critical performance criterion are presented below.

Average Number of Preignitions (AVPIE)
Unit of Measure: Square Root (AVPIE+0.5)

Reference Oil	Mean	Standard Deviation
221	3.3819	0.3775
224	2.0445	0.3775
224-1	2.0445	0.3775

Maximum Number of Preignitions (MAXPIE)
Unit of Measure: Square Root (MAXPIE+0.5)

Reference Oil	Targets
All Oils	N/A

B. Acceptance Criteria

1. New Test Stand/Engines

- A minimum of two (2) operationally valid calibration tests, with no Level 0 e_i or Level 2 Z_i alarms after the second operationally valid test must be conducted in a new stand-engine on any approved reference oils. If the above criteria cannot be met then a minimum of three (3) operationally valid calibration tests, with no Level 3 e_i or level 2 Z_i alarms after the third operationally valid test must be conducted in a new stand-engine on any approved reference oils.
- Following the necessary tests, check the status of the control charts and follow the prescribed actions.

2. Existing Test Stand/Engine

- The stand/engine must have previously been accepted into the system by meeting the LTMS requirements

- Existing test stand-engines that have run an acceptable reference in the past 180 days 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 stand-engines 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 221 and 224 or subsequent approved rebends in equal proportion with random assignment.

4. Control Charts

In Section 1, the construction of the control charts that contribute to the Lubricant Test Monitoring System is outlined. For the Sequence IX, $Z_0 = \text{Mean } Y_i$ of all operationally valid tests in the initial stand-engine calibration sequence. The constants used for the construction of the control charts for the Sequence IX, and the response necessary in the case of control chart limit alarms, are depicted below.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA Chart		Stand-Engine Prediction Error	
		Severity		Severity	
Chart Level	Limit Type	Lambda	Alarm	Limit Type	Limit
Stand-Engine		0.4		Level 0	±1.000
	Level 1		0.000	Level 1	±1.351
	Level 2		±1.500	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 and/or engine from the system.

- Exceed Stand-engine chart of Prediction Error (e_i)

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 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-engine that triggered the alarm. Evaluate the subsequent test(s) using Level 3 limit.

Level 1:

- The Level 1 limit applies in situations where a previously calibrated stand-engine has not been calibrated for two reference periods and is attempting to calibrate again. Immediately conduct one additional reference test in the stand-engine that triggered the alarm. Evaluate the subsequent test(s) using Level 3 limit.

Level 0:

- Immediately conduct one additional reference test in the stand-engine that triggered the alarm. Evaluate the subsequent test(s) using Level 3 limit.

- Exceed Stand EWMA of Standardized Test Result

(Z_i) Level 2:

- Conduct one additional reference test in the stand-engine that triggered the alarm. The stand-engine 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-engine 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:

$$\text{AVPIE SA} = (-Z_i) \times (0.3775)$$

$$\text{MAXPIE SA} = \text{AVPIE SA}$$

- When $\text{MAXPIE} \geq \text{AVPIE} + 1.3199$
 - Conduct one additional reference test in the stand-engine that triggered the alarm. The stand-engine that triggered the alarm is not qualified for non-reference tests until the alarm is cleared.

The following industry issues are handled by the TMC and do not require individual laboratory action.

- Exceed Industry EWMA of Standardized Test Result (Z_i)

Level 2:

- The 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.

5. Removal of Test Stand/Engines from the System

The laboratory must notify the TMC and the ACC Monitoring Agency when removing a stand/engine from the system. No reference oil data shall be removed from the control charts from test stand/engines that have been used for registered candidate oil testing. Reintroduction of a stand/engine into the system requires completion of new stand/engine acceptance requirements. The removal and reinstallation of the most recently calibrated engine back into the same test stand requires only a single successful calibration test, provided its previous calibration period has not expired.

35. L-60-1 LTMS Requirements

The following are the specific L-60-1 calibration test requirements.

A. Reference Oils and Parameters

The critical parameters are Viscosity Increase, Pentane Insolubles, Average Carbon/Varnish, and Average Sludge. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM L-60-1 Surveillance Panel. The means and standard deviations for the current reference oils for each critical and noncritical parameter are presented below.

VISCOSITY INCREASE

Unit of Measure: VISI

CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
131-3	81.451	7.659
131-4	75.944	7.659
148-1	36.966	7.659
151-2	37.070	2.717
155-2	23.000	2.832

PENTANE INSOLUBLES

Unit of Measure: PEN

CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
131-3	2.293	0.413
131-4	2.560	0.413
148-1	0.387	0.413
151-2	2.064	0.380
155-2	1.509	0.434

AVERAGE CARBON/VARNISH

Unit of Measure: ACV

CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
131-3	1.111	0.511
131-4	1.053	0.511
148-1	8.306	0.511
151-2	8.801	0.517
155-2	8.760	0.708

Sequence IX Oil Targets					
Oil	n	Effective Dates		AVGPIE	
		From ¹	To ²	\bar{X}	s ³
221	8 ⁴	4-21-17	6-27-19	3.3819	0.3609
221	8 ⁴	6-28-19	***	3.3819	0.3775
222	16 ⁴	4-21-17	***	4.2644	0.2694
224	9	6-28-19	***	2.0445	0.3775
224-1	9	5-1-23	***	2.0445	0.3775

- 1 Effective for all tests completed on or after this date.
- 2 *** = currently in effect.
- 3 Pooled s from matrix analysis.
- 4 Matrix + additional tests n-size.

L-60-1 Reference Oil Targets													
Oil	n	Effective Dates		Viscosity Increase		Pentane Insolubles		Toluene Insolubles		Average Carbon/Varnish		Average Sludge	
		From ¹	To ²	\bar{X}	s^3	\bar{X}	s^3	\bar{X}	s^3	\bar{X}	s^3	\bar{X}	s^3
131-3	30	6-3-94	***	81.451	7.659	2.293	0.413	0.554	0.249	1.111	0.511	9.411	0.106
131-4	--	11-2-95	***	75.944	7.659	2.560	0.413	0.923	0.249	1.053	0.511	9.483	0.106
133	9	8-23-00	***	93.691	7.659	2.801	0.413	1.405	0.249	6.548	0.511	9.381	0.106
143	30	6-3-94	***	31.500	7.659	1.271	0.413	0.914	0.249	9.002	0.511	9.503	0.106
148	30	6-3-94	***	36.966	7.659	0.387	0.413	0.257	0.249	8.306	0.511	9.532	0.106
148-1	--	3-11-02	8-9-23	36.966	7.659	0.387	0.413	0.257	0.249	8.306	0.511	9.532	0.106
151-2	9	8-23-00	***	37.070	2.717	2.064	0.380	1.329	0.394	8.801	0.517	9.382	0.106
155-1	17	6-7-14	2-10-16	27.176	3.127	1.388	0.372	1.035	0.451	8.971	0.436	9.441	0.106
155-1	20	2-11-16	8-11-16	27.750	3.242	1.490	0.529	1.135	0.639	8.875	0.678	9.435	0.103
155-1	35	8-12-16	9-15-23	28.800	3.669	1.509	0.434	1.109	0.530	8.760	0.586	9.426	0.101
155-2	35	8-1-23	2-20-24	28.800	3.669	1.509	0.434	1.109	0.530	8.760	0.586	9.426	0.101
155-2	35	8-1-23	***	23.000	2.832	1.509	0.434	1.109	0.530	8.760	0.708	9.426	0.101

- 1 Effective for all tests completed on or after this date.
- 2 *** = currently in effect.
- 3 Standard deviations are pooled s values for all oils except 151-2, 155-1, and 155-2.
- 4 155-2 Target Update on Feb 21, 2024 applied retroactively to all 155-2 runs since August 1, 2023.