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9. Sequence X LTMS Requirements

The following are the specific Sequence X calibration test requirements.

A. Reference Oils and Critical Performance Criteria

The critical parameter is Chain wear stretch (CHST). The reference oils required for test stand and test laboratory referencing are reference oils accepted by the ASTM Sequence X Surveillance Panel. The means and standard deviations for the current reference oils for each critical performance criterion are presented below.

Chain Wear Stretch
Unit of Measure: $\ln(\text{CHST})$

Reference Oil	Mean	Standard Deviation
270	-2.15699	0.17435
271	-2.60987	0.17537
1011	-2.08191	0.18882

B. Acceptance Criteria

3. 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.
- In addition to a calibration run, labs must also pass a discrimination run on reference oil 271. The discrimination run is to be run consecutively with the calibration test sample. The discrimination run is valid for not more than 360 days from date completed. The discrimination run does not calibrate the stand, but rather confirms that the discrimination oil test result can be discriminated from the calibration oil test result when run consecutively.

4. 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 oil 270 or subsequent approved reblends assigned 100% for oil 270.
- In addition to a calibration run, labs must also pass a discrimination run on reference oil 271. The discrimination run is to be run consecutively with the calibration test sample. The discrimination run is valid for not more than 360 days from date completed. The discrimination run does not calibrate the stand, but rather confirms that the discrimination oil test result can be discriminated from the calibration oil test result when run consecutively.

4. Control Charts

In Section 1, the construction of the control charts that constitute the Lubricant Test Monitoring System is outlined. For the Sequence X, $Z_0 = \text{Mean } Y_i$ of first two operationally valid tests in the stand. The constants used for the construction of the control charts for the Sequence X, 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	±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:

$$\text{Chain Stretch (ln(CHST))}: SA = (-Z_i) \times (0.17856)$$

The following are the steps that must be taken to determine the acceptability of the discrimination test:

After a successful calibration attempt with reference oil 270, conduct a reference test using reference oil 271 and chart the result for information purposes (do not include the result in the stand EWMA calculation)

- If 271 result is less than the lower Level 3 E_i limit (-2.066), discrimination criteria is met, that is discrimination test is passed. If not, if 271 result is within Level 3 E_i limit (-2.066 to 2.066), test is deemed normal and discrimination test is acceptable. If not compare the transformed result obtained with reference oil 270 with the 271 transformed result. If transformed chain stretch of 270 is at least 0.32362 greater than that obtained with reference oil 271, the discrimination test is acceptable. If none of the criteria are met, conduct another discrimination test using reference oil 271. Where multiple results have been conducted on reference oil 270, use the average of the results used to successfully calibrate the stand, for comparison with reference oil 271.
- 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.

48. D6594 High Temperature Corrosion Bench Test (HTCBT) LTMS Requirements

The following are the specific High Temperature Corrosion Bench Test calibration test requirements.

B. Calibration Details

The High Temperature Corrosion Bench Test is calibrated at the individual instrument level, by the bath used in the test. Baths are identified by ID number within a laboratory and calibrated individually. There is no laboratory level calibration in the High Temperature Corrosion Bench Test.

B. Reference Oils and Critical Parameters

The critical parameters are Copper Concentration and Lead Concentration, reported in milligrams per kilogram. The Change in Copper (Δ Cu) precision is not uniform across reference oils. A natural log transform (ln) is applied to each Δ Cu value before performing statistical evaluations. The reference oils required for instrument calibration are the reference oils accepted by the ASTM High Temperature Corrosion Bench Test Surveillance Panel. The means and standard deviations for the current reference oils for the critical parameters are presented below.

COPPER CONCENTRATION (CUC)

Unit of Measure: ln(mg/kg)

Reference Oil	Mean	Standard Deviation	Acceptance Band ^A
44-4	4.9961	0.1069	120 – 182
1005-5	1.8497	0.3363	3 – 12

^ATest results are compared to the Acceptance Bands in original units

LEAD CONCENTRATION (PBC)

Unit of Measure: mg/kg

Reference Oil	Mean	Standard Deviation	Acceptance Band
44-4	31.5	9.00	14 – 49
1005-5	9.5	7.60	0 – 24

C. Acceptance Criteria

1. New Instrument

- Operationally valid calibration tests, with results within the Acceptance Bands, must be conducted on both approved reference oils. No candidate oils shall be tested along with these runs.

2. Existing Instrument

- The instrument must have been TMC calibrated prior to LTMS introduction or previously accepted into the system by meeting LTMS calibration requirements.
- An operationally valid calibration test, with results within the Acceptance Bands, must be conducted on an approved reference oil, with every set of candidate test runs on the instrument.

3. Reference Oil Assignment

Once instruments have been accepted into the system, the TMC will assign reference oil for continuing calibration according to the following proportions:

- 75% on reference oil 1005-5 (or subsequent reblends)
- 25% on reference oil 44-4 (or subsequent reblends)

4. Control Charts

In Section 1, the construction of the control charts that constitute the Lubricant Test Monitoring System is outlined. The constants used for the construction of the control charts for the High Temperature Corrosion Bench Test, and the response necessary in the case of control chart limit alarms, are depicted below. The Shewhart Chart is used to initially determine the Acceptance Band on a new reference oil, prior to rounding those results to establish the official Acceptance Band for that parameter.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA Chart				Shewhart Chart	
		LAMBDA		K		K	
Chart Level	Limit Type	Precision	Severity	Precision	Severity	Precision	Severity
Stand	Action	--	--	--	--	--	1.96

The following are steps that must be taken in the case of a result outside the Acceptance Bands.

- Result outside the Acceptance Band (all parameters)
 - Conduct an additional calibration test.

5. Introduction of New or Re-Blended Reference Oils

Introduction of new or replacement reference oils will be conducted at the discretion of the surveillance panel. Participating laboratories may be asked to donate tests on the new oil(s) to establish baseline performance in the D6594 HTCBT. The number of tests requested will be sufficient to rigorously evaluate the oil's performance (typically a minimum of 3 tests per lab for all the participating labs). When possible, a previously approved reference oil should be run alongside the new or re-blended reference oil. Preliminary statistical performance targets and acceptance criteria will be established by the surveillance panel, and those values will be re-assessed as the TMC collects additional calibration data.