

10. Sequence IVB LTMS Requirements

The following are the specific Sequence IVB calibration test requirements.

A. Reference Oils and Critical Performance Criteria

The critical parameter is Average Volume Loss Intake Bucket Lifter (AVLI). 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

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	Level 1	0.3	0.000	Level 1	$\pm 1.351$
	Level 2		$\pm 1.800$	Level 2	$\pm 1.734$
				Level 3	$\pm 2.066$
Industry	Level 1	0.2	$\pm 0.775$	--	--
	Level 2		$\pm 0.859$	--	--

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:

$$\text{Average Volume loss Intake (sqrt(AVLI)): } SA = (-Z_i) \times (0.2003)$$

- 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 IVB Oil Targets					
Oil	n	Effective Dates		AVLI	
		From <sup>1</sup>	To <sup>2</sup>	$\bar{X}$	s
300	9	10-27-17	***	1.3931	0.2230
1011	9	10-27-17	***	1.2538	0.1932
1012	10	10-27-17	***	1.1543	0.1847

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

2 \*\*\* = currently in effect.

History of Industry Correction Factors  
Appendix B

Test Area	Effective		Condition	Correction
	From	To		
IIIF	June 13, 2010	***	Reference Tests	Adjust the Hours to 275 % Viscosity Increase by adding 10 hours.
			Non-reference Tests	Refer to Section 12.7.9.6 of Test Method D6984
IIIG	None		All Tests	None
IIIGA	None		All Tests	None
IIIGB	July 24, 2009	***	All Tests	Add 1.61 to PHOS
IIIH	July 1, 2015	***	All Tests	None
IIIIHA	July 1, 2015	***	All Tests	None
IIIIHB	July 1, 2015	***	All Tests	None
IVA	None		All Tests	None
IVB	None		All Tests	None
VG	July 1, 2005	November 9, 2007	All tests using fuel batch TF2221LS20	Add 0.19 to AEV
				Add 2.175 to AES and divide by 1.192
				Add 0.54 to APV
				Add 0.627 to RCS and divide by 1.041
	November 10, 2007	***	All tests using fuel batch TF2221LS20	Add 0.12 to AEV
				Add 0.42 to AES
				Add 0.39 to APV
	May 26, 2009	September 30, 2009	All tests using fuel batch XC2721NX10	Add 0.23 to RCS
				Add 3.011 to AEV and divide by 1.356
	October 1, 2009	***	All tests using fuel batch XC2721NX10	Add 1.325 to APV and divide by 1.207
Subtract 0.24 from APV				
September 25, 2013	***	All tests using fuel batch AK2821NX10-1	Subtract 0.12 from AEV	
			Adjust AES by equation: $AES + e^{\frac{[(AES-5.00)(AES-9.70)]}{351}}$	
			Adjust RAC by equation: $(RAC - 4.71)/0.49$	
			Subtract 0.757 from transformed OSCR	
All tests using fuel batch DJ0121NX10			Add 0.18 to AEV.	
All tests using fuel batch DJ0121NX10			None	
VH	None		All Tests	None
IX	None		All Tests	None

APPENDIX C  
HISTORY OF SEVERITY ADJUSTMENT (SA)  
STANDARD DEVIATIONS

Test	Parameter	s	Effective Dates	
			From	To
Sequence IIIF	VIS80	0.0129546	20000610	20130513
		0.0000000	20130514	***
	HRS	7.701	20130514	***
	APV	0.220	20000610	***
	WPD	0.658	20000610	***
	VIS60	0.17334	20011115	20130513
	VIS60	0.5*HRS SA	20130514	***
Sequence IIIG	PVIS	0.2919	20030501	***
	WPD	0.60	20030501	***
	ACW	0.1936	20030501	20040120
		0.1903	20040121	***
Sequence IIIGA	MRV Viscosity	0.30763	20031103	20040526
Sequence IIIGB	Phos. Retention	2.33	20081112	***
Sequence IIIH	PVIS	0.4641	20150701	***
	WPD	0.47	20150701	***
Sequence IIIIA	MRV Viscosity	0.4725	20150701	***
Sequence IIIIHB	Phos. Retention	1.53	20150701	***
Sequence IVA	ACW	9.47	19980819	20010524
		12.50	20010525	20050630
		12.52	20050701	20120208
		15.72	20120209	20120710
		14.87	20120711	***
Sequence IVB	AVLI	0.2003	20171027	***

REFERENCE OIL VISCOSITY GRADES (continued)

Oil	SAE Viscosity Grade <sup>1</sup>
539	10W-30
540 (GF5A)	5W-20
541 (GF5D)	10W-30
542 (GF5X)	0W-20
543	0W-16
544	5W-30
704	10W-30
809	15W-40
810	15W-40
811	15W-40
820 (PC-9A)	15W-40
821 (PC10E)	15W-40
822	15W-40
823 (PC11A)	10W30
830 (PC-9E)	15W-40
831 (PC10B)	15W-40
832 (PC11G)	15W-40
864 (X)	5W-30
866 (C)	10W-30
833 (PC11K)	15W-40
873	40
925	5W-30
940	5W-30
1004	15W-40
1005	15W-40
1006	5W-30
1007	5W-30
1008	5W-30
1009	5W-30
1010	5W-20
1011	0W-16
1012	5W-20
VOLC12	5W-30
VOLD12	0W-20
VOLE12	5W-20

<sup>1</sup> Viscosity grade applies to all subsequent reblends.



Sequence VIF Reference Oil Targets							
Oil	n	Effective Dates		FEI1		FEI2	
		From <sup>1</sup>	To <sup>2</sup>	$\bar{X}$	$s^3$	$\bar{X}$	$s^3$
542-2	6	11-22-15	***	2.23	0.18	1.52	0.13
1011	5	11-22-15	***	1.45	0.14	1.41	0.39
543	7	11-22-15	***	1.88	0.27	2.25	0.34

<sup>1</sup> Effective for all tests completed on or after this date.

<sup>2</sup> \*\*\* = currently in effect.

<sup>3</sup> Pooled s from precision matrix analysis.

L-37 Reference Oil Targets																	
Hardware	Pinion Batch	Oil	n	From	To	Ridging			Rippling			Spitting			Wear		
						$\bar{X}$	s	Bands	$\bar{X}$	s	Bands	$\bar{X}$	s	Bands	$\bar{X}$	s	Bands
NONLUBRICATED	V1L500	152-1	13	19000101	***	8.85	0.689	8 - 10	9.39	0.506	8 - 10	9.89	0.028	9.8 - 9.9	7.46	0.519	7 - 8
		155	15	19000101	***	9.07	0.594	8 - 10	9.33	0.488	8 - 10	9.84	0.124	9.6 - 10	7.47	0.516	7 - 8
	V1L686	127	9	19000101	***	7.00	2.000	3 - 10	7.56	1.236	5 - 10	9.71	0.643	9 - 10	6.67	0.500	6 - 8
		128-1	8	19000101	***	7.50	0.926	6 - 9	5.63	1.188	3 - 8	9.93	0.046	9.8 - 10	6.88	0.641	6 - 8
		129	2	19000101	***	9.50	0.707	8 - 10	10.00	0.000	10 - 10	10.00	0.000	10 - 10	8.00	1.414	5 - 10
		151-2	11	19000101	***	9.09	0.701	8 - 10	8.73	0.647	8 - 10	9.92	0.040	9.8 - 10	7.55	0.688	6 - 9
	151-3	1	19000101	***	9.00	0.000	9 - 9	8.00	0.000	8 - 8	9.90	0.000	9.9 - 9.9	7.00	0.000	7 - 7	
	V1L528	134	5	19000101	***	6.40	1.673	3 - 9	8.40	0.894	6 - 10	3.80	1.483	1 - 7	5.60	0.894	4 - 8
		152-1	8	19000101	***	8.75	0.707	7 - 10	8.63	0.916	7 - 10	9.45	1.003	7 - 10	7.00	0.500	6 - 8
		152-2	8	19000101	***	8.75	0.707	7 - 10	8.63	0.916	7 - 10	9.45	1.003	7 - 10	7.00	0.500	6 - 8
		155	9	19000101	***	8.56	0.882	7 - 10	8.44	1.014	6 - 10	8.70	1.578	5 - 10	6.78	0.441	6 - 8