2. Sequence IIIF LTMS Requirements

The following are the specific Sequence IIIF calibration test requirements.

A. Reference Oils and Parameters

The critical parameters are Percent Viscosity Increase at 80 Hours, Average Piston Varnish, Weighted Piston Deposits, and Screened Average Camshaft plus Lifter Wear. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM Sequence IIIF Surveillance Panel. The means and standard deviations for the current reference oils for each critical and noncritical parameter are presented below.

HOURS to 275% VISCOSITY INCREASE
Unit of Measure: Hours
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
433-1	121.09	7.701

AVERAGE PISTON VARNISH
Unit of Measure: Merits
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
433-1	9.30	0.300

WEIGHTED PISTON DEPOSITS
Unit of Measure: Merits
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
433-1	4.59	0.697

PERCENT VISCOSITY INCREASE @ 80 HOURS
Unit of Measure: 1/SQRT(VIS80)
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
433-1	0.1635099	0.0302263

PERCENT VISCOSITY INCREASE @ 60 HOURS
Unit of Measure: LN(VIS60)
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
433-1	3.55500	0.229905

B. Acceptance Criteria

1. New Test Stand

a. Less than six (6) Operationally Valid Calibration Results in Laboratory

- A minimum of two (2) operationally valid calibration tests, with no stand Shewhart severity alarms and no stand Shewhart precision alarms, must be conducted on any approved reference oils.

- All operationally valid calibration test results must be charted to determine if the test stand is currently "in control" as defined by the control charts from the Lubricant Test Monitoring System.

b. Six (6) or more Operationally Valid Calibration Results in Laboratory*

- The first operationally valid test run on any approved reference oil must have no stand Shewhart severity alarm and no stand Shewhart precision alarm using the "Reduced K" values. If the first operationally valid calibration test does not meet these acceptance criteria, then the New Test Stand criteria listed above in 1.a must be followed.

* Only test results from calibrated stands in the laboratory count towards the tally of six (6) required operationally valid calibration tests. The sixth test must be complete (date and time) before the first test completes (date and time) on a new test stand that is seeking calibration with a single test result. In addition, the first test for the stand is to begin within six (6) months of the completion of the last acceptable calibration test. Also, there must not be any outstanding precision alarms for the laboratory.

2. Existing Test Stand

- The test stand must have previously been accepted into the system by meeting LTMS calibration requirements.

- All operationally valid calibration test results must be charted to determine if the test stand is currently "in control" as defined by the control charts from the Lubricant Test Monitoring System.

- An existing Sequence IIIG test stand can be converted to an existing Sequence IIIF test stand by conducting one reference oil test, with no control chart alarms. The stand must have been previously calibrated as a Sequence IIIF stand and the reference oil test must

be completed within one year of the previous Sequence IIIF reference oil test on that stand.

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:

- 100% of the scheduled calibration tests should be conducted on reference oil 433 or subsequent approved 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 Sequence IIIF, and the response necessary in the case of control chart limit alarms, are depicted below. Note that control charting all parameters, except Stuck Rings, is required.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA				Shewhart Chart	
		LAMBDA		K		K	
Chart Level	Limit Type	Precision	Severity	Precision	Severity	Precision	Severity
Stand	Reduced K	--	--	--	--	1.70	1.48
	Action	0.3	0.3	2.00	2.24	2.00	1.80
Lab	Warning	0.3	--	2.00	--	--	--
	Action	0.3	0.2	2.72	1.96	2.00	1.80
Industry	Warning	0.2	0.2	2.00	2.24	--	--
	Action	0.2	0.2	2.65	2.88	--	--

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 engine from the system.

- Exceed EWMA laboratory chart action limit for precision (critical parameters only)
  - Cease all candidate starts in the laboratory. Develop plan to correct laboratory precision problem. Coordinate efforts with the TMC.
- Exceed EWMA laboratory chart warning limit for precision (critical parameters only)
  - Immediately begin two (2) calibration tests on calibrated test stands different from the test stand which exceeded the warning limit. (Calibration tests currently running on "existing" test stands may be used.) If a laboratory has two (2) test stands, conduct one (1) calibration test in each of those two (2) stands. If a laboratory has only one (1) test stand, conduct two (2) additional calibration tests in that test stand. Notify the TMC for potential laboratory visit. Candidate testing may continue on other calibrated test stands.

- Exceed EWMA test stand chart action limit for precision (critical parameters only)

  – Remove test stand from the system. Notify the TMC. Correct test stand precision problem. Follow requirements for entry of a new test stand into the system.

- Exceed Shewhart test stand chart action limit for precision (critical parameters only)

  – Conduct an additional calibration test.

- Exceed Shewhart laboratory chart action limit for precision (critical parameters only)

  – Notify TMC for guidance.

- Exceed EWMA laboratory chart action limit for severity (all parameters)

  – Calculate test laboratory Severity Adjustment (SA) for each parameter that exceeds the action limit. Use the current laboratory EWMA (Z_i) as follows:

HRS:	SA = $(-Z_i)$ x (7.701)
APV:	SA = $(-Z_i)$ x (0.220)
WPD:	SA = $(-Z_i)$ x (0.658)
VIS60:	SA =0.5* HRS SA

  – Confirm calculation with the TMC.

- Exceed EWMA test stand chart action limit for severity (critical parameters only)

  – Notify the TMC. If the direction of the test stand is deemed different from that of the laboratory, conduct an additional calibration test in the identified test stand. If this limit is still exceeded after the additional calibration test, then remove the test stand from the system, notify the TMC, correct test stand severity problem, and follow requirements for entry of a new test stand into the system.

- Exceed Shewhart test stand chart action limit for severity (critical parameters only)

  – Conduct an additional calibration test.

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

- Exceed EWMA industry chart action limit (critical parameters only)
  - TMC to notify test developer, surveillance panel chairman, and ACC Monitoring Agency. Meeting of TMC, test developer, and surveillance panel required to determine course of action.
- Exceed EWMA industry chart warning limit (critical parameters only)
  - TMC to notify test developer, surveillance panel chairman, and ACC Monitoring Agency. Coordination of TMC, test developer, and surveillance panel chairman required to discuss potential problem.

APPENDIX A

HISTORY OF LTMS REFERENCE OIL MEANS AND STANDARD DEVIATIONS

Sequence IIIF Reference Oil Targets														
Oil	n	Effective Dates		VIS80[3]		HRS		APV		WPD		SACLW	VIS60[4]	
		From[1]	To[2]	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	Maximum	$\bar{X}$	s
1006	6	6-10-00	11-14-01	0.0156989	0.0076717	- -	- -	9.14	0.263	3.29	0.284	20.0	- -	- -
	34	11-15-01	11-30-01	0.0156989	0.0076717	- -	- -	9.14	0.263	3.29	0.284	20.0	5.41732	0.230855
	35	12-1-01	8-1-03	0.0167362	0.0086503	- -	- -	9.23	0.213	3.32	0.327	20.0	5.41732	0.230855
1006-2	5	1-9-02	10-31-02	0.0496678	0.0090039	- -	- -	9.35	0.283	4.18	0.417	20.0	5.30933	0.168340
	14	11-1-02	6-30-03	0.0490642	0.0065297	- -	- -	9.46	0.203	4.04	0.407	20.0	5.41527	0.160503
	22	7-1-03	1-21-04	0.0461786	0.0079007	- -	- -	9.38	0.227	4.00	0.459	20.0	5.43687	0.171445
	30	1-22-04	5-13-13	0.0440739	0.0102981	- -	- -	9.35	0.223	3.94	0.448	20.0	5.46088	0.166630
1008	6	6-10-00	3-31-01	0.0872279	0.0087680	- -	- -	9.73	0.115	4.66	0.861	20.0	- -	- -
	24	4-1-01	9-4-01	0.0895442	0.0098604	- -	- -	9.75	0.102	4.57	0.803	20.0	- -	- -
	37	9-5-01	11-14-01	0.0899551	0.0096670	- -	- -	9.74	0.100	4.52	0.773	20.0	- -	- -
	38	11-15-01	5-13-13	0.0899551	0.0096670	- -	- -	9.74	0.100	4.52	0.773	20.0	4.21605	0.122356
1008-1[6]	--	5-16-02	4-20-03	0.0899551	0.0096670	- -	- -	9.74	0.100	4.52	0.773	20.0	4.21605	0.122356
	10	4-21-03	6-20-04	0.0911968	0.0063810	- -	- -	9.75	0.099	4.75	0.823	20.0	4.34110	0.139270
	20	6-21-04	5-13-13	0.0930792	0.0059248	- -	- -	9.77	0.103	4.57	0.699	20.0	4.33528	0.118673
433	5	6-10-00	11-14-01	0.1601833	0.0204379	- -	- -	9.41	0.257	4.96	0.697	20.0	- -	- -
	19	11-15-01	5-13-13	0.1601833	0.0204379	- -	- -	9.41	0.257	4.96	0.697	20.0	3.31554	0.111867
433-1	5	8-15-01	11-14-01	0.1700213	0.0433403	121.09	5.752	9.31	0.242	4.28	0.826	20.0	- -	- -
	6	11-15-01	2-28-02	0.1700213	0.0433403	121.09	5.752	9.31	0.242	4.28	0.826	20.0	3.41045	0.111867[5]
	11	3-1-02	2-23-03	0.1684402	0.0402156	121.09	5.752	9.27	0.281	4.27	0.557	20.0	3.55682	0.298299
	22	2-24-03	2-23-04	0.1643104	0.0321605	121.09	5.752	9.30	0.306	4.57	0.760	20.0	3.59344	0.227054
	31	2-24-04	6-12-10	0.1635099	0.0302263	121.09	5.752	9.30	0.300	4.59	0.697	20.0	3.55500	0.229905
	30	6-13-10	4-30-13	0.1635099	0.0302263	121.09	7.701	9.30	0.300	4.59	0.697	20.0	3.55500	0.229905
	30	5-1-13	***	0.1635099	0.0302263	121.09	7.701	9.30	0.300	4.59	0.697	N/A	3.55500	0.229905

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

2 *** = currently in effect.

3 Transformation is 1/Sqrt(VIS80).

4 Transformation is ln(VIS60).

5 Standard deviation based on oil 433.

6 Initial targets based on oil 1008.

APPENDIX B

HISTORY OF INDUSTRY CORRECTION FACTORS
APPLICABLE TO LTMS DATA

Test Area	Effective	Description
IIIF	May 14, 2013	For reference oil tests completing on or after June 13, 2010, adjust the Hours to 275 % Viscosity Increase by adding 10 hours.
		For all non-reference tests refer to Section 12.7.9.6 of Test Method D6984
IIIG	None	None
IIIGA	None	None
IIIGB	July 24, 2009	Add 1.61 to PHOS
IVA	None	None
VG	July 1, 2005	For 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	For Fuel Batch TF2221LS20, Add 0.12 to AEV; Add 0.42 to AES ; Add 0.39 to APV; Add 0.23 to RCS
	May 26, 2009	For Fuel Batch XC2721NX10, Add 3.011 to AEV and divide by 1.356; Add 1.325 to APV and divide by 1.207
	October 1, 2009	For Fuel Batch XC2721NX10, Subtract 0.24 from APV; subtract 0.12 from AEV.
VIB	None	None
VID	None	None
VIII	None	None
1M-PC	None	None
1K	None	None
1N	May 1, 2004	Add -1.135 to ln(TLHC+1)
1P	None	None
1R	None	None
C13	None	None
ISB	April 21, 2011	For Batch B Tappets with Batch E, F, and G Cams; Multiply ATWL by 0.637; Add -9.5 to ACSW
ISB	December 11, 2011	For Batch C Tappets with Batch H Cams; Multiply ATWL by 0.637; Add -9.5 to ACSW
ISB	November 13, 2012	For Batch C Tappets with Batch H and J Cams; Multiply ATWL by 0.711; Add -5.6 to ACSW
ISM	June 28, 2007	Add +1.7 to Crosshead Wear At 3.9% Soot Add +19.1 to Injector Adjusting Screw Wear At 3.9% Soot
	March 4, 2010	Add +1.3 to Crosshead Wear At 3.9% Soot
	April 30, 2011	Add +2.5 to Crosshead Wear At 3.9% Soot
T-8	September 17,2011	Add +0.40 to Viscosity Increase at 3.8% Soot
T-8E	September 17,2011	Add +0.08 to Relative Viscosity at 4.8% Soot (50% DIN Shear Loss) Add +0.09 to relative Viscosity at 4.8% Soot (100% DIN Shear Loss)
T-10A	None	None

APPENDIX C

HISTORY OF SEVERITY ADJUSTMENT (SA)
STANDARD DEVIATIONS

Test	Parameter	s	Effective Dates	
			From	To
Sequence IIIF	VIS80	0.0129546	20000610	20130513
	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	***
	ACLW	0.1936	20030501	20040120
		0.1903	20040121	***
Sequence IIIGA	MRV Viscosity	0.30763	20031103	20040526
Sequence IIIGB	Phos. Retention	2.33	20081112	***
Sequence IVA	ACW	9.47	19980819	20010524
		12.50	20010525	20050630
		12.52	20050701	20120208
		15.72	20120209	20120710
		14.87	20120711	***