26. T-13 LTMS Requirements

The following are the specific T-13 calibration test requirements.

A. Reference Oils and Critical Performance Criteria

The critical performance criteria are IR Oxidation Peak Height at 360 hours and percent increase in 40° kinematic viscosity from 300 to 360 hours. The reference oils required for test stand and test laboratory referencing are reference oils accepted by the ASTM T-13 Test Development Task Force. The means and standard deviations for the current reference oils for each critical performance criterion are presented below.

T-13 FTIR Peak Height Oxidation
Unit of Measure: absorbance / cm

Reference Oil	Mean	Standard Deviation
823	127.4	11.1
823-1	109.3	11.1

Percent Increase in Viscosity at 40°C from 300 to 360 hour
Unit of Measure: SQRT(%)

Reference Oil	Mean	Standard Deviation
823	8.610	0.929
823-1	8.139	0.929

B. Acceptance Criteria

1. New Test Lab

   a. The first two stands in a laboratory

      - A minimum of two (2) operationally valid calibration tests and/or matrix tests, with no Level 3 e_i alarms must be conducted in a new laboratory 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

   b. Third and subsequent stands in a laboratory

      - New test stands in an existing lab, and 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.

- For an existing test stand in an existing lab run one 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:

- 100% of the scheduled calibration tests should be conducted on reference oil 823 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. For the T-13, Z_0=Mean Y_i of first two operationally valid tests in the laboratory. The constants used for the construction of the control charts for the T-13, 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		Laboratory Prediction Error	
		Severity		Severity	
Chart Level	Limit Type	Lambda	Alarm	Limit Type	Limit
Lab	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 Laboratory 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 the 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.

  Level 1:

  – The Level 1 limit also applies to stand in an existing test lab that has not run an acceptable reference in the past two years. The stand can calibrate with one test if the Level 1 limits are not exceeded. Otherwise, immediately conduct another reference test in the stand.

- Exceed Laboratory EWMA of Standardized Test Result (Z_i)

  Level 2:

  – Immediately conduct one additional reference test in the engine-stand that triggered the alarm. The engine-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 engine-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 laboratory severity adjustment (SA). Calculate the laboratory SA as follows and confirm the calculation with the TMC:

  T-13 FTIR Peak Height Oxidation: $SA = (-Z_i) \times (11.1)$

  Percent Increase in Viscosity at 40°C from 300 to 360 hour: $SA = (-Z_i) \times (0.929)$

- 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.

T-13 Reference Oil Targets							
		Effective Dates		IR Oxidation Peak Height absorbance / cm		% Increase in Viscosity at 40°C from 300 to 360 hour[2]	
Oil	n	From[1]	To[2]	$\overline{X}$	s	$\overline{X}$	s
PC11A	6	10-01-2014	11-24-2015	142.7	12.4	9.303	1.212
PC11A	6	11-25-2015	***	127.4	11.1	8.610	0.929
PC11B	3	10-01-2014	***	59.7	12.4	4.690	1.212
PC11C	4	10-01-2014	***	121.1	12.4	8.146	1.212
PC11D	7	10-01-2014	***	133.5	12.4	8.676	1.212
PC11E	7	10-01-2014	***	59.2	12.4	4.606	1.212
PC11F	4	10-01-2014	***	123.6	12.4	9.044	1.212
823(PC11A)	-	05-01-2015	11-24-2015	142.7	12.4	9.303	1.212
823(PC11A)	-	11-25-2015	***	127.4	11.1	8.610	0.929
823-1	5	05-01-2023	***	109.3	11.1	8.139	0.929

1 Effective for all tests completed on or after this date.
2 *** = currently in effect
3 SQRT Transformation adopted 20151019

Test Area	Effective From	Effective To	Condition	Description
1M-PC	None		All Tests	None
1K	None		All Tests	None
1N	May 1, 2004	September 27, 2005	All Tests	Add -1.135 to ln(TLHC+1)
	September 28, 2005	March 31,2015	All Tests	Add -0.451 to ln(TLHC+1)
	April 1,2015	***	All Tests on 1Y3998 Liners	Add 0.419954 to ln(TGF+1)
1P	None		All Tests	None
1R	None		All Tests	None
C13	None		All Tests	None
COAT	20190510	***	Batch A Oil Filters	Multiply AAVE4050 by 0.9606
	20221118	***	Batch B Oil Filters	Multiply AAVE4050 by 0.9310
ISB	April 21, 2011	October 18, 2017	All tests using batch B tappets with batch E, F, and G cams	Multiply ATWL by 0.637; Add -9.5 to ACSW
	December 11, 2011	November 12, 2012	All tests using batch C tappets with batch H cams	Multiply ATWL by 0.637; Add -9.5 to ACSW
	November 13, 2012	October 18, 2017	All tests using batch C tappets with batch H and J cams	Multiply ATWL by 0.711; Add -5.6 to ACSW
	None	October 18, 2017	All test using batch D tappets and batch K cams	Multiply ATWL by 1; Add -11.3 to ACSW
	October 19, 2017	September 3,2020	All tests using batch K cams with batch D tappets and batch E crossheads	Multiply ATWL by 0.7851; Add -18.5 to ACSW
	September 4, 2020	***	All tests using batch K cams with batch D tappets	Multiply ATWL by 0.7851; Multiply ACSW by 0.94
	September 4, 2020	***	All tests using batch L cams with batch E tappets	Multiply ATWL by 0.7851; Multiply ACSW by 0.77
	September 4, 2020	***	All tests using batch M cams with batch F tappets and batch F crossheads (and subsequent batches)	Multiply ATWL by 0.92; Multiply ACSW by 0.77

Test Area	Effective		Condition	Description
	From	To		
ISM	June 28, 2007	March 3,2010	All Tests	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	April 29,2011	All Tests	Add +1.3 to Crosshead Wear At 3.9% Soot
	April 30, 2011	***	All tests on crosshead batches through batch F	Add +2.5 to Crosshead Wear At 3.9% Soot
	November 19, 2013	September 30, 2014	All Tests	Add -0.200 to ln(SAIAS)
	October 1, 2014	***	All Tests	Add 4 kPa to Oil Filter Delta Pressure
			All tests using batch C injector push rods, batch D injector adjusting screws and batch F crossheads	Add + 0.410 to ln(SAIAS)
	January 1, 2020	***	All tests using batch G crossheads	Add +0.6 to Crosshead Wear At 3.9% Soot
	***	***	All tests using batch C injector push rods, batch E injector adjusting screws, batch G and subsequent batch crossheads	Add + 0.250 to ln(SAIAS)
T-8	September 17, 2011	***	All Tests	Add +0.40 to Viscosity Increase at 3.8% Soot
T-8E	September 17,2011	***	All Tests	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-11	September 14, 2005	***	All Tests	Add -0.39% to Soot @ 12cSt Vis. Inc., Add 1274 cP to MRV Vis
	December 6, 2005	***	All Tests	Add -0.36% to Soot @ 12cSt Vis. Inc., Add 713 cP to MRV Vis.
	March 24, 2006	***	All Tests	Add -0.35% to Soot @ 12cSt Vis. Inc., Add 956 cP to MRV Vis.
				Multiply Average Cylinder Liner Wear by 0.946
				$\Delta Lead_{Final}$ = exp[(ln(ΔLead) x 0.923)]
				$\Delta Lead\ (250\text{-}300)_{Final}$ = exp[(ln(ΔLead 250-300) x 0.956)]
				OC = exp[(ln($OC_{100\text{-}300}$) x 0.961)]

Test Area	Effective		Condition	Description
	From	To		
T-12	***	***	All tests using UUXO Hardware	Multiply Average Top Ring Weight Loss by 0.849
				Multiply Average Cylinder Liner Wear by 0.566
				$\Delta Lead_{Final} = \exp[(\ln(\Delta Lead) \times 0.797)]$
				$\Delta Lead\ (250\text{-}300)_{Final} = \exp[(\ln(\Delta Lead\ 250\text{-}300) \times 0.700)]$
				$OC = \exp[(\ln(OC_{100\text{-}300}) \times 0.916)]$
	***	***	All tests using VXYPD Hardware	Multiply Average Top Ring Weight Loss by 0.846
				$ALW_{Final} = \exp[(\ln(ALW) \times 0.743)]$
				If $OC_{100\text{-}300} > 65.0$ $\Delta Lead_{Final} = \exp[(\ln(\Delta Lead) + (65.0 - OC_{100\text{-}300}) \times 0.03234]$ If $OC_{100\text{-}300} \leq 65.0$ $\Delta Lead_{Final} = \Delta Lead$
				If $OC_{100\text{-}300} > 65.0$ $\Delta Lead(250\text{-}300)_{Final} = \exp[\ln(\Delta Lead(250\text{-}300) + (65.0 - OC_{100\text{-}300}) \times 0.04089]$ If $OC_{100\text{-}300} \leq 65.0$ $\Delta Lead(250\text{-}300)_{Final} = \Delta Lead(250\text{-}300)$
				$OC = \exp[(\ln(OC_{100\text{-}300}) \times 0.926)]$

Test Area	Effective		Condition	Description
	From	To		
T-13	***	***	All Tests on Batch B Cylinder and subsequent liners	Transformed Result + 0.857
RFWT	None		All Tests	None
EOAT	None		All Tests	None
T-12A	None		All Tests	None
DD13	None		All Tests	None