16. C13 LTMS Requirements

The following are the specific C13 calibration test requirements.

A. Reference Oils and Parameters

The critical parameters are Top Groove Carbon, Top Land Carbon, Oil Consumption Delta, and Second Ring Top Carbon. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM C13 Surveillance Panel. The mean and standard deviation for the current reference oils for test parameters are presented below.

TOP GROOVE CARBON
Unit of Measure: Demerits

Reference Oil	Mean	Standard Deviation
831	46.02	5.90
831-1	46.02	5.90
831-2	46.02	5.90

TOP LAND CARBON
Unit of Measure: Demerits

Reference Oil	Mean	Standard Deviation
831	21.87	7.89
831-1	21.87	7.89
831-2	21.87	7.89

OIL CONSUMPTION DELTA
Unit of Measure: SQRT (g/h)

Reference Oil	Mean	Standard Deviation
831	5.5089	0.7141
831-1	5.5089	0.7141
831-2	5.5089	0.7141

SECOND RING TOP CARBON
Unit of Measure: LN (Demerits)

Reference Oil	Mean	Standard Deviation
831	2.8828	0.2900
831-1	2.8828	0.2900
831-2	2.8828	0.2900

B. Acceptance Criteria

1. New Test Stand

   a. First Test Stand in a Laboratory

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

   b. All Subsequent New Test Stands in a Laboratory

      - One operationally valid test with no stand Shewhart severity alarms must be conducted on any approved reference oil.

2. Existing Test Stand

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

   - One operationally valid test with no stand Shewhart severity alarms must be conducted on any approved reference oil.

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 following reference oil mix:

   - 100% of the scheduled calibration tests should be conducted on reference oil 831 (or subsequent approved reblends).

4. Control Charts

   In Section 1, the construction of the four control charts that constitute the Lubricant Test Monitoring System is outlined. The constants used for the construction of the control charts for the C13, and the response necessary in the case of control chart limit alarms, are depicted below.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA Chart				Shewhart Chart	
		LAMBDA		K		K	
Chart Level	Limit Type	Precision	Severity	Precision	Severity	Precision	Severity
Stand	Action	0.3	0.3	1.80	2.10	1.80	2.00
Industry	Warning	0.2	0.2	1.74	2.05	--	--
	Action	0.2	0.2	2.58	2.81	--	--

The following are the steps that must be taken in the case of exceeding control chart limits.

- Exceed Shewhart test stand chart limit for severity
  - 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
  - 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
  - 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.

17. ISB LTMS Requirements

The following are the specific ISB calibration test requirements.

A. Reference Oils and Parameters

The critical parameters are Average Cam Shaft Wear and Average Tappet Weight Loss. The reference oils required for test stand and test laboratory calibration are reference oils accepted by the ASTM Cummins Test Surveillance Panel. The mean and standard deviation for the current reference oils for each critical parameter are presented below.

AVERAGE CAM SHAFT WEAR
Unit of Measure: Micrometers

Reference Oil	Mean	Standard Deviation
831	42.5	5.0
831-1	42.5	5.0
831-2	42.5	5.0

AVERAGE TAPPET WEIGHT LOSS
Unit of Measure: Milligrams

Reference Oil	Mean	Standard Deviation
831	97.2	14.8
831-1	97.2	14.8
831-2	97.2	14.8

B. Acceptance Criteria

1. New Test Stand

   a. First Test Stand in a Laboratory

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

   b. All Subsequent New Test Stands in a Laboratory

   - One operationally valid test with no stand Shewhart severity alarms must be conducted on any approved reference oil.

2. Existing Test Stand

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

- One operationally valid test test with no stand Shewhart severity alarms must be conducted on any approved reference oil.

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 following reference oil mix:

- 100% of the scheduled calibration tests should be conducted on reference oil 831 (or subsequent approved reblends).

4. Control Charts

In Section 1, the construction of the four control charts that constitute the Lubricant Test Monitoring System is outlined. The constants used for the construction of the control charts for the ISB, and the response necessary in the case of control chart limit alarms, are depicted below.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA Chart				Shewhart Chart	
		LAMBDA		K		K	
Chart Level	Limit Type	Precision	Severity	Precision	Severity	Precision	Severity
Stand	Action	0.3	0.3	2.10	2.36	2.10	1.96
Industry	Warning	0.2	0.2	2.10	2.36	--	--
	Action	0.2	0.2	2.80	3.00	--	--

The following are the steps that must be taken in the case of exceeding control chart limits.

- Exceed Shewhart test stand chart limit for severity
  - 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
  - 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
  - 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.

C13 Reference Oil Targets											
		Effective Dates		Top Groove Carbon		Top Land Carbon		Oil Consumption Δ^2		2nd Ring Top Carbon[3]	
Oil	n	From	To[1]	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s
PC10A	3	5-28-05	2-20-06	45.55	6.44	23.18	5.57	6.2676	0.8226	2.3301	0.3430
PC10C	2	5-28-05	2-20-06	54.57	2.92	26.98	0.21	5.7229	1.8966	3.2447	0.3966
PC10D	3	5-28-05	2-20-06	39.18	5.85	23.58	2.33	3.8405	1.8509	2.4426	0.3400
PC10E	7	5-28-05	2-20-06	45.52	8.02	23.52	7.02	4.8593	1.4265	2.8197	0.4024
PC10F	3	5-28-05	2-20-06	54.08	11.09	36.32	2.82	6.5929	0.9750	3.8424	0.2573
PC10G	3	5-28-05	2-20-06	35.85	2.83	29.05	0.84	3.8066	0.8456	2.7134	0.1936
831 (PC10B)	8	5-28-05	3-12-08	45.18	7.42	24.99	7.59	5.7336	0.7280	2.8945	0.2055
	14	3-13-08	***	46.02	5.90	21.87	7.89	5.5089	0.7141	2.8828	0.2900
831-1[4]	--	05-10-08	***	46.02	5.90	21.87	7.89	5.5089	0.7141	2.8828	0.2900
831-2[4]	--	08-06-13	***	46.02	5.90	21.87	7.89	5.5089	0.7141	2.8828	0.2900

1 *** = Currently in effect
2 Transformation for Oil Consumption Delta is sqrt(OC Δ)
3 Transformation for 2nd Ring Top Carbon is ln(R2TC)
4 Targets based on oil 831

ISB Reference Oil Targets							
Oil	n	Effective Dates		Average Camshaft Wear		Average Tappet Weight Loss	
		From	To[1]	$\overline{X}$	s	$\overline{X}$	s
821 (PC10E)	6	6-4-05	12-31-05	34.6	4.6	56.2	9.6
830-2	6	6-4-05	12-31-05	39.8	9.0	85.9	16.0
831 (PC10B)	6	6-4-05	1-24-07	41.9	5.6	88.7	15.9
	10	1-25-07	8-6-07	42.8	5.4	94.9	15.3
	14	8-7-07	***	42.5	5.0	97.2	14.8
831-1[2]	--	8-7-07	***	42.5	5.0	97.2	14.8
831-2[2]	--	8-6-13	***	42.5	5.0	97.2	14.8

1 *** = currently in effect
2 Targets based on oil 831

APPENDIX B

HISTORY OF INDUSTRY CORRECTION FACTORS

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
IVA	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
				Add 0.23 to RCS
	May 26, 2009	September 30, 2009	All tests using 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	***	All tests using fuel batch XC2721NX10	Subtract 0.24 from APV
				Subtract 0.12 from AEV
	September 25, 2013	***	All tests using fuel batch AK2821NX10-1	Adjust AES by equation: $AES + e^{[(AES-5.00)(AES-9.70)]/351}$
				Adjust RAC by equation: $(RAC - 4.71)/0.49$
				Subtract 0.757 from transformed OSCR
				Add 0.18 to AEV.
VIB	None		All Tests	None
VID	None		All Tests	None
VIII	None		All Tests	None

APPENDIX B (continued)
HISTORY OF INDUSTRY CORRECTION FACTORS

Test Area	Effective		Condition	Description
	From	To		
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	***	All Tests	Add -0.451 to ln(TLHC+1)
1P	None		All Tests	None
1R	None		All Tests	None
C13	None		All Tests	None
ISB	April 21, 2011	***	All tests using batch B tappets with batch E, F, and G cams	Multiply ATWL by 0.637; Add -9.5 to ACSW
ISB	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
ISB	November 13, 2012	***	All tests using batch C tappets with batch H and J cams	Multiply ATWL by 0.711; Add -5.6 to ACSW
ISM	June 28, 2007	***	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	***	All Tests	Add +1.3 to Crosshead Wear At 3.9% Soot
	April 30, 2011	***	All Tests	Add +2.5 to Crosshead Wear At 3.9% Soot
	November 19, 2013	***	All Tests	Add -0.200 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-10A	None		All Tests	None

APPENDIX B (continued)
HISTORY OF INDUSTRY CORRECTION FACTORS

Test Area	Effective		Condition	Description
	From	To		
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.
T-12	***	***	All tests using batch R piston ring & cylinder liner hardware	Multiply Average Cylinder Liner Wear by 0.58
	***	May 18, 2011	All Tests SWTN Hardware	Multiply Average Top Ring Weight Loss by 0.95
				Multiply Average Cylinder Liner Wear by 0.86
				$\Delta Lead_{Final}$ = exp[(ln(ΔLead) x 0.95)]
				$\Delta Lead\ (250\text{-}300)_{Final}$ = exp[(ln(ΔLead 250-300) x 1.03)]
	May 19, 2011	June 4, 2012	All tests using SWTN Hardware	Multiply Average Top Ring Weight Loss by 0.92
				Multiply Average Cylinder Liner Wear by 0.83
				$\Delta Lead_{Final}$ = exp[(ln(ΔLead) x 0.92)]
				$\Delta Lead\ (250\text{-}300)_{Final}$ = exp[(ln(ΔLead 250-300) x 0.93)]
				OC = exp[(ln($OC_{100\text{-}300}$) x 0.95)]
				Multiply Average Top Ring Weight Loss by 0.92
	June 5, 2012	***	All tests using SWTN Hardware	Multiply Average Top Ring Weight Loss by 0.705
				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)]
	***	***	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(ΔLead) x 0.797)]
				$\Delta Lead\ (250\text{-}300)_{Final}$ = exp[(ln(ΔLead 250-300) x 0.700)]
				OC = exp[(ln($OC_{100\text{-}300}$) x 0.916)]
RFWT	None		All Tests	None
EOAT	None		All Tests	None

APPENDIX B (continued)
HISTORY OF INDUSTRY CORRECTION FACTORS
APPLICABLE TO LTMS DATA

Test Area	Effective From	Effective To	Condition			Description
L-33-1			None			None
L37	20010612	***	V1L686/P4L626A Non-reference	Lubrited Ring	Canadian	Ridging add 0.9922
	20040825	***	V1L686/P4L626A Non-reference	Lubrited Pinion & Ring	Canadian	Ridging add 0.6065
	***	***	L247/T758A Non-reference	Lubrited Pinion	Canadian	Ridging add 0.5878, Pitting/Spalling add 0.7340
	***	20130514	V1L528/P4T883A Non-reference	Nonlubrited Pinion	Standard	Ridging add 0.3365, Rippling add 0.3365
					Canadian	Rippling add 0.7885
				Lubrited Pinion	Standard	Ridging add 0.3365
					Canadian	Ridging add 0.5878, Rippling add 0.5878
				Lubrited Ring	Canadian	Ridging add 0.3365
	20130515	***	V1L528/P4T883A Non-reference	Nonlubrited Pinion	Standard	Ridging add 0.3365, Rippling add 0.3365
					Canadian	Rippling add 0.7566
				Lubrited Pinion	Standard	Ridging add 0.3365
					Canadian	Ridging add 0.5878, Rippling add 0.5878
				Lubrited Ring	Canadian	Ridging add 0.3365
L-42			None			None
L-60-1			None			None
HTCT			None			None
OSCT			None			None