22. ISB Viscosity 108 (ISBV108) LTMS Requirements

The following are the specific ISBV108 calibration test requirements.

A. Reference Oils and Parameters

The critical parameter is Soot at 12.0 cSt Viscosity Increase. Soot at 4.0 cSt Viscosity Increase, Soot at 15.0 cSt Viscosity Increase, and MRV Viscosity are noncritical parameters. 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 critical and noncritical parameters are presented below.

SOOT @ 4.0 cSt VISCOSITY INCREASE
Unit of Measure: %
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
834	3.81	0.220

SOOT @ 12.0 cSt VISCOSITY INCREASE
Unit of Measure: %
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
834	4.40	0.257

SOOT @ 15.0 cSt VISCOSITY INCREASE
Unit of Measure: %
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
834	4.48	0.296

MRV VISCOSITY
Unit of Measure: cP
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
834	7522	373.5

B. Acceptance Criteria

1. New Test Lab

a. A New Test Lab is one that has never been in calibration before for either the ISBV108 or the ISBV156 test method.

- A minimum of two (2) operationally valid calibration tests with no Level 3 e_i or Level 2 Z_i alarms on the SOOT @ 12.0 cSt and SOOT @ 15.0 cSt parameters after the second operationally valid test must be conducted in a new Lab on any approved reference oils using the ISBV108 test method. If the above criteria cannot be met, then a minimum of three (3) operationally valid calibration tests, with no Level 3 ei or Level 2 Zi alarms after the third operationally valid test must be conducted in a new Lab on any approved reference oils.

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

- Z_0 = Mean Yi of all operationally valid tests in the initial Stand calibration for all test parameters.

2. New Test Stand within an existing Test Lab via ISBV108 or ISBV156 test method

- The test Lab must have been ASTM TMC calibrated previously and accepted into the system by meeting LTMS calibration requirements for either the ISBV108 or the ISBV156 test method.

- A minimum of 1 operationally valid calibration test result with a $|Yi| < 1.0$ is required for the Stand calibration for the SOOT @ 12.0 cSt and SOOT @ 15.0 cSt parameters. If this criterion cannot be met, then a minimum of two (2) operationally valid calibration tests, with no Level 3 ei or Level 2 Zi alarms after the second operationally valid test must be conducted on the Stand on any approved reference oils.

- Z_0 = Mean Yi of all operationally valid tests in the initial Stand calibration procedure whether it be through (1), (2) or more tests that are required to achieve initial calibration with no Level 3 e_i or Level 2 Z_i alarms on critical parameters.

- All operationally valid calibration tests 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.

3. Reference Oil Assignment

Once test stands have been accepted into the system, the TMC will assign reference oils for continuing calibration.

4. Control Charts

In Section 1, the construction of the control charts that constitute the Lubricant Test Monitoring System is outlined. Z_0=mean Y_i of all ISBV108 tests needed to initially calibrate the Stand. In an already existing calibrated Lab (via the ISBV108 and/or ISBV156), a new Stand requires a minimum of 1 test provided that $|Yi| < 1.0$ for the SOOT @ 12.0 cSt and SOOT @ 15.0 cSt parameters in that test. The constants used for the construction of the control charts for the ISBV108, and the responses necessary in the case of control chart limit alarms, are depicted below.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA Chart		Shewhart Chart	Stand Prediction Error	
Chart Level	Lambda	Limit Type	Limit	New Stand in Existing Lab	Limit Type	Limit
Stand	0.3	Level 1	0	±1.0	Level 1	±1.351
		Level 2	±1.800		Level 2	±1.734
			--		Level 3	±2.066
Industry	0.2	Level 1	±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 Shewhart Chart Limit (Y_i) on a New Stand in Existing Lab

  Alarm (Soot @ 12cst and Soot @ 15cst parameters only):

  - 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 analysis (refer to Section 1.A.5) has been performed.

- Exceed Stand chart of Prediction Error (e_i)

  Level 3 (critical parameters only):

  - 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 analysis (refer to Section 1.A.5) has been performed.

Level 2 (critical parameters only):

- 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. Evaluate any subsequent test(s) using Level 3 e_i limits.

Level 1 (critical parameters only):

- The Level 1 limit also applies to a 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, conduct another reference test in the Stand.

- Exceed Stand EWMA of Standardized Test Result (Z_i)

Level 2 (critical parameters only):

- 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 (all parameters except MRV Viscosity):

- 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:

- Calculate stand Severity Adjustment (SA) using the current laboratory EWMA (Z_i) as follows:

Soot at 4.0 cSt Viscosity Increase:	$SA = (-Z_i) \times (0.220)$
Soot at 12.0 cSt Viscosity Increase:	$SA = (-Z_i) \times (0.257)$
Soot at 15.0 cSt Viscosity Increase:	$SA = (-Z_i) \times (0.296)$

- Confirm calculations with the TMC.

- 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.

23. ISB Viscosity 156 (ISBV156) LTMS Requirements

The following are the specific ISBV156 calibration test requirements.

A. Reference Oils and Parameters

The critical parameter is Soot at 12.0 cSt Viscosity Increase. Soot at 4.0 cSt Viscosity Increase, Soot at 15.0 cSt Viscosity Increase, and MRV Viscosity are noncritical parameters. 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 critical and noncritical parameters are presented below.

SOOT @ 4.0 cSt VISCOSITY INCREASE
Unit of Measure: %
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
822-2	3.07	0.271

SOOT @ 12.0 cSt VISCOSITY INCREASE
Unit of Measure: %
CRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
822-2	6.09	0.301

SOOT @ 15.0 cSt VISCOSITY INCREASE
Unit of Measure: %
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
822-2	6.46	0.293

MRV VISCOSITY
Unit of Measure: cP
NONCRITICAL PARAMETER

Reference Oil	Mean	Standard Deviation
822-2	14125	827.9

B. Acceptance Criteria

1. New Test Lab

b. A New Test Lab is one that has never been in calibration before for either the ISBV108 or the ISBV156 test method.

- A minimum of two (2) operationally valid calibration tests with no Level 3 e_i or Level 2 Z_i alarms on the SOOT @ 12.0 cSt and SOOT @ 15.0 cSt parameters after the second operationally valid test must be conducted in a new Lab on any approved reference oils using the ISBV156 test method. If the above criteria cannot be met, then a minimum of three (3) operationally valid calibration tests, with no Level 3 ei or Level 2 Zi alarms after the third operationally valid test must be conducted in a new Lab on any approved reference oils.

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

- Z_0 = Mean Yi of all operationally valid tests in the initial Stand calibration for all test parameters.

2. New Test Stand within an existing Test Lab via ISBV108 or ISBV156 test method

- The test Lab must have been ASTM TMC calibrated previously and accepted into the system by meeting LTMS calibration requirements for either the ISBV108 or the ISBV156 test method.

- A minimum of 1 operationally valid calibration test result with a $|Yi| < 1.0$ is required for the Stand calibration for the SOOT @ 12.0 cSt and SOOT @ 15.0 cSt parameters. If this criterion cannot be met, then a minimum of two (2) operationally valid calibration tests, with no Level 3 ei or Level 2 Zi alarms after the second operationally valid test must be conducted on the Stand on any approved reference oils.

- Z_0 = Mean Yi of all operationally valid tests in the initial Stand calibration procedure whether it be through (1), (2) or more tests that are required to achieve initial calibration with no Level 3 e_i or Level 2 Z_i alarms on critical parameters.

- All operationally valid calibration tests 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.

3. Reference Oil Assignment

Once test stands have been accepted into the system, the TMC will assign reference oils for continuing calibration.

4. Control Charts

In Section 1, the construction of the control charts that constitute the Lubricant Test Monitoring System is outlined. Z_0=mean Y_i of all ISBV156 tests needed to initially calibrate the Stand. In an already existing calibrated Lab (via the ISBV108 and/or ISBV156), a new Stand requires a minimum of 1 test provided that $|Yi| < 1.0$ for the SOOT @ 12.0 cSt and SOOT @ 15.0 cSt parameters in that test. The constants used for the construction of the control charts for the ISBV156, and the responses necessary in the case of control chart limit alarms, are depicted below.

LUBRICANT TEST MONITORING SYSTEM CONSTANTS

		EWMA Chart		Shewhart Chart	Stand Prediction Error	
Chart Level	Lambda	Limit Type	Limit	New Stand in Existing Lab	Limit Type	Limit
Stand	0.3	Level 1	0	±1.0	Level 1	±1.351
		Level 2	±1.800		Level 2	±1.734
			--		Level 3	±2.066
Industry	0.2	Level 1	±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 Shewhart Chart Limit (Y_i) on a New Stand in Existing Lab

  Alarm (Soot @ 12cst and Soot @ 15cst parameters only):

  - 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 analysis (refer to Section 1.A.5) has been performed.

- Exceed Stand chart of Prediction Error (e_i)

  Level 3 (critical parameters only):

  - 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 analysis (refer to Section 1.A.5) has been performed.

Level 2 (critical parameters only):

- 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. Evaluate any subsequent test(s) using Level 3 e_i limits.

Level 1 (critical parameters only):

- The Level 1 limit also applies to a 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, conduct another reference test in the Stand.

- Exceed Stand EWMA of Standardized Test Result (Z_i)

  Level 2 (critical parameters only):

  – 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 (all parameters except MRV Viscosity):

  – 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:

– Calculate stand Severity Adjustment (SA) using the current laboratory EWMA (Z_i) as follows:

Soot at 4.0 cSt Viscosity Increase:	$SA = (-Z_i) \times (0.271)$
Soot at 12.0 cSt Viscosity Increase:	$SA = (-Z_i) \times (0.301)$
Soot at 15.0 cSt Viscosity Increase:	$SA = (-Z_i) \times (0.293)$

– Confirm calculations with the TMC.

- 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.

39. Oil Seal Compatibility Test LTMS Requirements

The following are the specific Oil Seal Compatibility Test calibration test requirements.

A. Reference Oils and Critical Parameters

The critical parameters are Elongation, Shore Hardness, and Volume Change. The reference oils required for test stand and test laboratory calibration are the reference oils accepted by the ASTM Oil Seal Compatibility Test Surveillance Panel. The means and standard deviations for the current reference oils for the critical parameters are presented below.

ELONGATION
Unit of Measure: Percent

Reference Oil	Elastomer	Mean	Standard Deviation
160-1	Polyacrylate	23.04	14.289
160-1	Fluoroelastomer	-47.65	5.506
161-1	Polyacrylate	68.88	17.850
161-1	Fluoroelastomer	-34.57	6.989
161-1	Nitrile	10.43	10.691
162	Nitrile	-65.35	7.330
168	Nitrile	-74.52	6.965
169	Polyacrylate	49.2	21.82
169	Fluoroelastomer	-39.5	6.99
169	Nitrile	-16.2	10.69
170	Nitrile	-70.68	3.007
171	Polyacrylate	25.090	11.415
171	Fluoroelastomer	-47.949	5.947

SHORE HARDNESS
Unit of Measure: Points

Reference Oil	Elastomer	Mean	Standard Deviation
160-1	Polyacrylate	-1.8	1.16
160-1	Fluoroelastomer	1.6	1.36
161-1	Polyacrylate	-24.9	2.83
161-1	Fluoroelastomer	1.6	1.30
161-1	Nitrile	-16.1	2.18
162	Nitrile	2.0	2.03
168	Nitrile	3.0	1.89
169	Polyacrylate	-16.0	2.83
169	Fluoroelastomer	0.1	1.30
169	Nitrile	-8.6	2.18
170	Nitrile	1.500	0.718
171	Polyacrylate	0.223	1.858
171	Fluoroelastomer	0.987	1.664

VOLUME CHANGE
Unit of Measure: Percent

Reference Oil	Elastomer	Mean	Standard Deviation
160-1	Polyacrylate	0.343	0.4473
160-1	Fluoroelastomer	2.053	0.4075
161-1	Polyacrylate	19.624	1.4348
161-1	Fluoroelastomer	6.199	0.7080
161-1	Nitrile	18.444	1.7057
162	Nitrile	2.460	1.5821
168	Nitrile	1.326	1.4730
169	Polyacrylate	13.1	1.43
169	Fluoroelastomer	4.4	0.71
169	Nitrile	11.8	1.71
170	Nitrile	2.325	0.341
171	Polyacrylate	-0.088	1.096
171	Fluoroelastomer	2.167	1.201

B. Acceptance Criteria

1. New Test Stand

   - For each elastomer type, an operationally valid calibration test, with no Shewhart severity alarms, must be conducted on each of the two approved reference oils.

2. Existing Test Stand

   - The test stand must have been TMC calibrated prior to LTMS introduction or previously accepted into the system by meeting LTMS calibration requirements.

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:

Elastomer Type	Oil Assignments
PA	Assign reference oils 160, 161, 169 or 171 (or subsequent reblends) for every calibration sequence.
FL	Assign reference oils 160, 161, 169 or 171 (or subsequent reblends) for every calibration sequence.
NI	Assign reference oils 161, 162, 168, 169 or 170 (or subsequent reblends) for every calibration sequence.

ISBV108 Reference Oil Targets											
		Effective Dates		Soot @ 4.0 cSt Vis. Inc		Soot @ 12.0 cSt Vis. Inc		Soot @ 15.0 cSt Vis. Inc.		MRV Viscosity	
Oil	n	From	To[1]	$\overline{X}$	S	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s
834	14	4-20-2014	***	3.81	0.22	4.40	0.257	4.48	0.296	7522	373.5

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

ISBV156 Reference Oil Targets											
		Effective Dates		Soot @ 4.0 cSt Vis. Inc		Soot @ 12.0 cSt Vis. Inc		Soot @ 15.0 cSt Vis. Inc.		MRV Viscosity	
Oil	n	From	To[1]	$\overline{X}$	S	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s
822-2	11	4-20-24	***	3.07	0.271	6.09	0.301	6.46	0.293	14125	827.9

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

Oil Seal Compatibility Test Reference Oil Targets										
			Effective Dates		Elongation		Shore Hardness		Volume Change	
Oil	n	Elastomer	From[1]	To[2]	$\overline{X}$	s	$\overline{X}$	s	$\overline{X}$	s
160[3]	--	Polyacrylate	11-18-94	***	23.04	14.289	-1.8	1.16	0.343	0.4473
	--	Fluoroelastomer	11-18-94	***	-47.65	5.506	1.6	1.36	2.053	0.4075
160-1	144	Polyacrylate	11-18-94	***	23.04	14.289	-1.8	1.16	0.343	0.4473
	141	Fluoroelastomer	11-18-94	***	-47.65	5.506	1.6	1.36	2.053	0.4075
161[4]	--	Polyacrylate	11-18-94	***	68.88	17.850	-24.9	2.83	19.624	1.4348
	--	Fluoroelastomer	11-18-94	***	-34.57	6.989	1.6	1.30	6.199	0.7080
	--	Nitrile	11-18-94	***	10.43	10.691	-16.1	2.18	18.444	1.7057
161-1	144	Polyacrylate	11-18-94	***	68.88	17.850	-24.9	2.83	19.624	1.4348
	141	Fluoroelastomer	11-18-94	***	-34.57	6.989	1.6	1.30	6.199	0.7080
	119	Nitrile	11-18-94	***	10.43	10.691	-16.1	2.18	18.444	1.7057
162	119	Nitrile	11-18-94	***	-65.35	7.330	2.0	2.03	2.460	1.5821
168	13	Nitrile	7-7-06	2-28-09	-74.22	2.422	3.0	1.49	1.424	0.1295
	38	Nitrile	3-1-09	3-10-09	-74.52	1.599	3.0	0.79	1.326	0.1388
	38	Nitrile	3-11-09	***	-74.52	6.965[5]	3.0	1.89[5]	1.326	1.4730[5]
169	19	Polyacrylate	3-7-12	***	49.2	21.82	-16.0	2.83[6]	13.1	1.430[6]
	18	Fluoroelastomer	3-7-12	***	-39.5	6.99[6]	0.1	1.30[6]	4.4	0.71[6]
	22	Nitrile	3-7-12	***	-16.2	10.69[6]	-8.6	2.18[6]	11.8	1.710[6]
170	12	Nitrile	1-24-16	8-20-18	-72.75	3.416	1.500	0.674	2.275	0.449
	32	Nitrile	8-21-18	9-9-24	-70.68	3.007	2.325	0.341	1.500	0.718
	32	Nitrile	9-10-24	***	-70.68	3.007	1.500	0.718	2.325	0.341
171	3	Polyacrylate	8-21-18	5-26-20	24.167	20.929	0.333	0.577	-0.233	0.306
171	3	Fluoroelastomer	8-21-18	5-26-20	-42.6	4.2	-0.667	0.577	1.467	0.306
171	40	Polyacrylate	5-27-20	***	25.090	11.415	0223	1.858	-0.088	1.096
171	39	Fluoroelastomer	5-27-20	***	-47.949	5.947	0.987	1.664	2.167	1.201

1 Effective for all tests completed on or after this date.
2 *** = currently in effect.
3 Targets based on oil 160-1.
4 Targets based on oil 161-1.
5 Standard deviation based on oil 162 (n=138).
6 Standard deviation based on oil 161-1.