

7. VH LTMS Requirements

The following are the specific VH calibration test requirements.

A. Reference Oils and Critical Performance Criteria

The critical performance criteria are Average Engine Sludge (AES), Rocker Cover Sludge (RAC), Average Engine Varnish (AEV50), and Average Piston Varnish (APV50). Number of Hot Stuck Rings is a discrete parameter and is monitored for occurrence only. The reference oils required for test stand and test laboratory referencing are reference oils accepted by the ASTM Sequence V Surveillance Panel. The means and standard deviations for the current reference oils for each critical performance criterion are presented below.

## AVERAGE ENGINE SLUDGE (AES)

Unit of Measure: Merits

Reference Oil	Mean	Standard Deviation
931	8.00	0.60
940	6.47	0.49
1011	8.43	0.57
1011-1	8.43	0.57

## ROCKER COVER SLUDGE (RAC)

Unit of Measure:  $\ln(10\text{-RAC})$ 

Reference Oil	Mean	Standard Deviation
931	0.2283	0.5715
940	0.8041	0.2340
1011	-0.5294	0.1924
1011-1	-0.5294	0.1924

## AVERAGE ENGINE VARNISH (AEV50)

Unit of Measure: Merits

Reference Oil	Mean	Standard Deviation
931	8.97	0.30
940	8.77	0.28
1011	9.26	0.21
1011-1	9.43	0.21

## AVERAGE PISTON VARNISH (APV50)

Unit of Measure: Merits

Reference Oil	Mean	Standard Deviation
931	8.35	0.60
940	7.35	0.64
1011	8.67	0.48
1011-1	8.96	0.48

## NUMBER OF HOT STUCK RINGS

Unit of Measure: Count

Reference Oil	Maximum Allowable
931	0
940	0
1011	0
1011-1	0

Any test failing on hot stuck rings is not chartable and must be re-run.

B. Acceptance Criteria

1. New Test Lab – a minimum of three valid calibration tests are required to establish a new 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<sub>i</sub> 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 may calibrate with one test provided e<sub>i</sub> 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 oils 940, 1009 and 1011 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 VH,  $Z_0 = \text{Mean } Y_i$  of first three operationally valid tests in the laboratory. The constants used for the construction of the control charts for the VH, 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
Industry	Level 1	0.2	±0.775	Level 3	±2.066
	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 new stands in an existing test lab or a previously calibrated stand that has not been calibrated for two reference periods and is attempting to calibrate again. 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. Do not update the severity adjustments until the Level 2 alarm is cleared. 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:

RAC ( $\ln(10-RAC)$ ):	$SA = (-Z_i) \times (0.2194)$
AES:	$SA = (-Z_i) \times (0.50)$
AEV50:	$SA = (-Z_i) \times (0.25)$
APV50:	$SA = (-Z_i) \times (0.53)$

- 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.

Sequence VH Reference Oil Targets												
Oil	n	Effective Dates		AES		RAC		AEV50		APV50		Hot Stuck Rings
		From <sup>1</sup>	To <sup>2</sup>	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	$\bar{X}$	s	Maximum Allowable
931	6	20210316	***	8.00	0.60	0.2283	0.5715	8.97	0.30	8.35	0.60	0
940	7	20170128	20221129	6.47	0.49	0.9155	0.2260	8.77	0.28	7.35	0.64	0
940	7 <sup>3</sup>	20221130 <sup>3</sup>	***	6.47	0.49	0.8041	0.2340	8.77	0.28	7.35	0.64	0
1009	8	20170128	20211115	7.21	0.44	0.0515	0.3139	8.81	0.40	7.89	0.74	0
1011	7	20170128	***	8.43	0.57	-0.5294	0.1924	9.26	0.21	8.67	0.48	0
1011-1	7	20220104	***	8.43	0.57	-0.5294	0.1924	9.43	0.21	8.96	0.48	0

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

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

3 Rocker Cover target recalculated for reference oil 940 recalculated using all results on fuel batch DJ0321NX10, number of tests =21, severity adjustments recalculated using new targets.