Sequence IVA Valve Train Wear Evaluation
Final Report Cover Sheet

Form 1

VERSION *IVA VERSION 20030416*

CONDUCTED FOR
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

C	V = VALID
	I = INVALID

CC	NR = Non-reference oil
	RO = Reference oil

Test Number			
Test Stand	Number of Runs on Since Last Calibration Test		Laboratory Run Number
CCCCC	*CCCC*		
Lab Engine Number	*CCCCCCCCCCCCCCCCCCCC*	Total Runs on Cylinder Head	*CCCCC*
Lab Head Number	*CCCCCCCCCCCCCCCCCCCC*	Lab Cam Number	*CCCCCCCCCCCCCCCCCCCC*
Date Completed	*YYYYMMDD*	Completion Time	*HH:MM*
Oil Code	*CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC*	Fuel Batch	*CCCCCCCCCC*
Formulation/Stand Code	*CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC*		
Alternate Codes:	*CCCCCCCCCCCCCCC*	*CCCCCCCCCCCCCCC*	*CCCCCCCCCCCCCCC*

In my opinion this test *cccccccc* been conducted in a valid manner in accordance with the ASTM Research Report RR-D2-XXXX and the appropriate amendments through the Information Letter System. The remarks included in this report describe anomalies associated with this test.

SUBMITTED BY:

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
Testing Laboratory

Signature Image
Signature

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Typed Name

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
Title

Sequence IVA Valve Train Wear Evaluation

Form 2

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Sequence IVA Valve Train Wear Evaluation

Form 3

Summary of Test Method

The Sequence IVA engine valve train wear test is a fired engine-dynamometer lubricant test which evaluates the ability of a test lubricant to reduce camshaft lobe wear. The test method is a low temperature cyclic test, with a total running duration of 100 hours.

A 1994 Nissan model KA24E water-cooled, 4 cycle, in-line cylinder, 2.4L engine is used as the test apparatus. The engine incorporates a single overhead cam (SOHC), three valves per cylinder (2 intake; 1 exhaust), and sliding follower valve train design. An engine short block is utilized for 12 tests; a cylinder head assembly for 6 tests; and the critical test parts (camshaft, rocker arms, rocker shafts) are replaced every test. A 95-minute break-in schedule is conducted whenever the long block or cylinder head is replaced (before tests 1 and 7).

The Sequence IVA test is a flush and run type of lubricant test. Each individual test consists of two 20-minute flushes, followed by the 100-hour cyclic test. The cyclic test is comprised of 100 hourly cycles. Each cycle consists of two stages. The idle speed Stage 1 duration is 50 minutes; the 1500 r/min stage 2 operates for 10 minutes. The stages of the test cycle are set at the following conditions:

Parameter	**Units**	**Stage 1**	**Stage 2**
Duration	min	50	10
Engine Speed	r/min	800	1500
Engine Torque	N•m	25	
Coolant Out Temperature	°C	50	55
Oil Cylinder Head Temperature	°C	49	59
Intake Air Temperature	°C	32	
Intake Air Pressure	kPa	0.050	
Intake Air Humidity	G/kg	11.5	
Exhaust Pressure	kPa absolute	103.5	
Coolant Flow	L/min	30	
Fresh Air Flow	SL/min	10	

Upon test completion, the camshaft is removed from the engine and measured for individual lobe wear at seven prescribed locations (nose; 14 degrees before and after the nose; 10 degrees before and after the nose; 4 degrees before and after the nose). For each lobe, the seven locations are summed to determine the lobe wear. Then the twelve lobes are averaged to compute the final test result.

Sequence IVA Valve Train Wear Evaluation

Form 4

Results Summary

Laboratory: *CC*	Test Number: *CCCCC - CCCC -*	Oil Code: *cccccccccccccccccccccccccccccccccc*
Formulation/Stand Code: *CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC*		

Laboratory Oil	*cccccccccccccccccccc*	Fuel Batch	*CCCCCCCCCC*	SAE Grade	*CCCCCCC*
Date Started	*YYYYMMDD*	Date Completed	*YYYYMMDD*	Test Length	*S1234*
Time Started	*HH:MM*	Time Completed	*HH:MM*	TMC Oil Code[A]	*CCCCCC*
Lab Engine	*CCCCCCCCCCCCCCCCCCCC*				
Cam Lot Number	*CCCCCC*	Head Lot	*CCCCCC*	Rocker Arm Lot	*CCCCCC*

Average Camshaft Wear

Original Unit Result, µm	*S1234.12*
Transformed Result	*S1234.12*
Industry Correction Factor	*S12.123*
Corrected Transformed Result	*S12.123*
Severity Adjustment (non-reference oil tests only)	*S12.123*
Final Transformed Result	*S1234.12*
Final Original Unit Result, µm	*S123.12*

Additional Camshaft Lobe Wear Measurements

Intake Lobe	Maximum, µm	*S123.12*
	Average, µm	*S123.12*
Exhaust Lobe	Maximum, µm	*S123.12*
	Average, µm	*S123.12*
Nose	Maximum, µm	*S123.12*
	Average, µm	*S123.12*

Additional Information

Total Oil Consumption @ EOT, g	*S123456*
Fuel Dilution @ EOT, %	*S123.12*
Fuel Consumption @ EOT, kg	*S123.12*
Fe by ICP @ EOT, ppm	*AAAAAA*
Corrected Blowby, L/min @ hour 5	*S1234.12*
Corrected Blowby, L/min @ hour 100	*S1234.12*

Most Recent Reference Oil Test History[B]			
Test Number	*CCCCC - CCCC -*		
Oilcode	*CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC*		
Date	*YYYYMMDD*	TMC Oil Code	*CCCCCC*
Final Average Camshaft Wear, µm	*S123.12*		

[A] Reference Oil Tests Only

[B] Non-reference Oil Tests Only

Sequence IVA Valve Train Wear Evaluation

Form 5

Camshaft Lobe Wear

Laboratory: *CC*	Test Number: *CCCCC - CCCC -*	Oil Code: *cccccccccccccccccccccccccccccccc*
Formulation/Stand Code: *CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC*		

7-point Measurement Method

Position	Cylinder	Lobe Number	14° BTC Wear, µm	10° BTC Wear, µm	4° BTC Wear, µm	0° (Nose) Wear, µm	4° ATC Wear, µm	10° ATC Wear, µm	14° ATC Wear, µm	Lobe Wear, µm
Intake	1	1	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
		3	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
	2	4	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
		6	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
	3	7	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
		9	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
	4	10	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
		12	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
	Maximum		*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
	Average		***S123.12***	***S123.12***	***S123.12***	***S123.12***	***S123.12***	***S123.12***	***S123.12***	***S123.12***
Exhaust	1	2	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
	2	5	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
	3	8	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
	4	11	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
	Maximum		*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
	Average		*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
Overall Maximum			*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*	*S123.12*
Overall Average			***S123.12***	***S123.12***	***S123.12***	***S123.12***	***S123.12***	***S123.12***	***S123.12***	***S1234.12***

Sequence IVA Valve Train Wear Evaluation

Form 6
Operational Summary

Laboratory: *CC*	Test Number: *CCCCC - CCCC -*	Oil Code: *cccccccccccccccccccccccccccccccc*
Formulation/Stand Code: *CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC*		

	Parameter	Units	QI Limit	EOT QI	Target		Average		Samples[A]	BQD[B]	Over/Under Range[C]
Controlled Parameters	Speed	r/min	0.000	*S123.12*	800	1500	*S1234.12*	*S1234.12*	*S1234567*	*S1234567*	*S1234567*
	Torque	N·m	0.000	*S123.12*	25.0		*S1234.12*	*S1234.12*	*S1234567*	*S1234567*	*S1234567*
	Coolant Out Temperature	°C	0.000	*S123.12*	50.0	55.0	*S1234.12*	*S1234.12*	*S1234567*	*S1234567*	*S1234567*
	Humidity	g/kg	0.000	*S123.12*	11.5		*S1234.12*		*S1234567*	*S1234567*	*S1234567*
	Intake Air Temperature	°C	0.000	*S123.12*	32		*S1234.12*		*S1234567*	*S1234567*	*S1234567*
	Intake Air Pressure	kPa	0.000	*S123.12*	0.05		*S123.123*		*S1234567*	*S1234567*	*S1234567*
	Exhaust Pressure, absolute	kPa	0.000	*S123.12*	103.5		*S1234.12*		*S1234567*	*S1234567*	*S1234567*
	Engine Coolant Flow	L/min	0.000	*S123.12*	30		*S1234.12*		*S1234567*	*S1234567*	*S1234567*
	Oil Cylinder Head Temperature	°C	0.000	*S123.12*	49.0	59.0	*S1234.12*	*S1234.12*	*S1234567*	*S1234567*	*S1234567*
	Rocker Cover Fresh Air Flow	SL/min	0.000	*S123.12*	10.0		*S1234.12*		*S1234567*	*S1234567*	*S1234567*

	Parameter	Units	Typical Values		Average	
Non-controlled Parameters	Oil Sump Temperature	°C	49 – 54	57 – 65	*S1234.12*	*S1234.12*
	Oil Gallery Temperature	°C	46.5 – 50.5	58.5 – 61.5	*S1234.12*	*S1234.12*
	Coolant In Temperature	°C	44 – 46	49 – 50	*S1234.12*	*S1234.12*
	Exhaust Gas Temperature	°C	306 – 332	414 – 434	*S1234.12*	*S1234.12*
	Fuel Rail Temperature	°C	15 – 30	15 – 30	*S1234.12*	*S1234.12*
	Oil Gallery Pressure	°C	99.5 – 145.5	210.5 – 280.5	*S1234.12*	*S1234.12*
	Oil Cylinder Head Pressure	kPa	30 – 60	50 – 90	*S1234.12*	*S1234.12*
	Fuel Pressure	kPa	230 – 380	230 – 380	*S1234.12*	*S1234.12*
	Manifold Vacuum	kPa	57.7 – 59.9	63.8 – 65.8	*S1234.12*	*S1234.12*
	Air-to-Fuel Ratio	-	14.1 – 14.7	14.1 – 14.7	*S123.12*	*S123.12*
	Crankcase Pressure	kPa	-0.1 – -0.4	-0.1 – -0.4	*S1234.12*	*S1234.12*
	Fuel Flow	kg/h	1.2 – 1.4	2.0 – 2.2	*S1234.12*	*S1234.12*
	Ignition Timing	°BTDC	9 – 11	22 – 26	*S1234.12*	*S1234.12*
	Ambient Temperature	°C	20 – 45	20 – 45	*S1234.12*	*S1234.12*
	Rocker Cover Gas Temperature	°C	47 – 49	52 – 55	*S1234.12*	*S1234.12*
	Rocker Cover Coolant Flow	L/min	3.0 – 4.5	3.0 – 4.5	*S1.12*	*S1.12*

[A] Total number of data points taken as determined from test length and sampling rate
[B] Number of Bad Quality Data points not used in the calculation of statistical measures
[C] Number of points clipped by over or under range limits of the statistical measures

Sequence IVA Valve Train Wear Evaluation

Form 7

Used Oil Analysis

Laboratory: *CC*	Test Number: *CCCCC - CCCC -*	Oil Code: *cccccccccccccccccccccccccccccccccccccc*
Formulation/Stand Code: *CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC*		

Chemical Analysis of 0, 25, 50, 75, & 100-hour Used Engine Oil Samples

ASTM Method	Analysis Description	Units	*CCC*	*CCC*	*CCC*	*CCC*	*CCC*
D445	Kinematic Viscosity @ 40°C	cSt	*S123.12*				*S123.12*
D3525-M	Fuel Dilution, Gasoline	%					
D5185 (ICP)	Iron by ICP	ppm		*AAAAAA*	*AAAAAA*	*AAAAAA*	*AAAAAA*
D5185 (ICP)	Copper by ICP	ppm		*AAAAAA*	*AAAAAA*	*AAAAAA*	*AAAAAA*

Sequence IVA Valve Train Wear Evaluation

Form 8
Camshaft Bore/Journal Measurements

Laboratory: *CC*	Test Number: *CCCCC - CCCC -*	Oil Code: *cccccccccccccccccccccccccccccccccc*
Formulation/Stand Code: *CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC*		

Camshaft Bearing Bore Diameter (mm)

Bore Gauge Set: 33.000mm — Diameter (Standard): 33.000 – 33.025mm

Bore Number	X		V		Y		Maximum Run-out	
	F	R	F	R	F	R	F	R
1	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*
2	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*
3	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*
4	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*
5	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*

Camshaft Bearing Journal Diameter (mm)

Diameter (Standard): 32.935 – 32.955mm — Clearance (Limit): 0.120mm

Bore Number	V		H		Run-out		Clearance @ V	
	F	R	F	R	F	R	F	R
1	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*
2	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*
3	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*
4	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*
5	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*	*S123.123*

Note: Calculate camshaft bearing clearance @ vertical bore diameter

Camshaft End Play, mm	*S123.123*	End Play (Limit): 0.20mm
Camshaft Sprocket Run-out, mm	*S123.123*	Run-out (Limit): 0.12mm
Camshaft Run-out (bend), mm	*S123.123*	Run-out (Limit): 0.02mm

Cylinder Compression, kPa

Cylinder Number	1	2	3	4
Before Test	*S12345*	*S12345*	*S12345*	*S12345*

Sequence IVA Valve Train Wear Evaluation

Form 9

Special Maintenance Record

Laboratory: CC	Test Number: CCCCC - CCCC -	Oil Code: cccccccccccccccccccccccccccccccccc
Formulation/Stand Code: CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC		

Number of Downtime Occurrences		S1	
Test Hours	**Date**	**Down Time**	**Reasons**
CCCCCC	CCCCCCCC	CCCCCC	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
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CCCCCC	CCCCCCCC	CCCCCC	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
CCCCCC	CCCCCCCC	CCCCCC	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
		HHH:MM	**Total Downtime**

Other Comments	
Number of Comment Lines	S1

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Sequence IVA Valve Train Wear Evaluation

Form 9A

Special Maintenance Record

Laboratory: CC	Test Number: CCCCC - CCCC -	Oil Code: cccccccccccccccccccccccccccccccc
Formulation/Stand Code: CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC		

Number of Downtime Occurrences		S1	
Test Hours	**Date**	**Down Time**	**Reasons**
CCCCCC	CCCCCCCC	CCCCCC	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC

Sequence IVA Valve Train Wear Evaluation

Form 9B

Special Maintenance Record

Laboratory: CC	Test Number: CCCCC - CCCC -	Oil Code: cccccccccccccccccccccccccccccccc
Formulation/Stand Code: CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC		

Number of Downtime Occurrences		S1	
Test Hours	**Date**	**Down Time**	**Reasons**
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CCCCCC	CCCCCCCC	CCCCCC	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC
		HHH:MM	**Total Downtime**

Other Comments	
Number of Comment Lines	S1

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Sequence IVA Valve Train Wear Evaluation

Form 10

Cycle 5 Stage 2 to 1 Transition: Oil Cylinder Head Temperature

Laboratory: CC	Test Number: CCCCC - CCCC -	Oil Code: cccccccccccccccccccccccccccccccc
Formulation/Stand Code: CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC		

CCCCCCCCC

Sequence IVA Valve Train Wear Evaluation

Form 11

Laboratory: CC	Test Number: CCCCC - CCCC -	Oil Code: cccccccccccccccccccccccccccccccc
Formulation/Stand Code: CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC		

CCCCCCCCC

Sequence IVA Valve Train Wear Evaluation

Form 12

Laboratory: CC	Test Number: CCCCC -CCCC -	Oil Code: cccccccccccccccccccccccccccccccccc
Formulation/Stand Code: CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC		

CCCCCCCCC

Sequence IVA Valve Train Wear Evaluation

Form 13

Laboratory: CC	Test Number: CCCCC -CCCC -	Oil Code: cccccccccccccccccccccccccccccccccc
Formulation/Stand Code: CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC		

CCCCCCCCC

Sequence IVA Valve Train Wear Evaluation

Form 14

Laboratory: CC	Test Number: CCCCC - CCCC -	Oil Code: cccccccccccccccccccccccccccccccc
Formulation/Stand Code: CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC		

CCCCCCCCC

Sequence IVA Valve Train Wear Evaluation

Form 15

Laboratory: CC	Test Number: CCCCC - CCCC -	Oil Code: cccccccccccccccccccccccccccccc
Formulation/Stand Code: CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC		

CCCCCCCCC

Sequence IVA Valve Train Wear Evaluation

Form 16

Laboratory: CC	Test Number: CCCCC -CCCC -	Oil Code: cccccccccccccccccccccccccccccccc
Formulation/Stand Code: CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC		

CCCCCCCCC

Sequence IVA Valve Train Wear Evaluation

Form 17

Laboratory: *CC*	Test Number: *CCCCC* - *CCCC* -	Oil Code: *cccccccccccccccccccccccccccccccccccccc*
Formulation/Stand Code: *CC-CCCCCCCCCC-C-C-CCCCCC-CC-CC-CCCCC*		

CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC