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APPROVED BY ASTM HQ: 12/6/00
(DATE)

SEQUENCE VG INFORMATION LETTER 00-3
Sequence No. 6

September 25, 2000

ASTM consensus has not been obtained on this information letter. An appropriate ASTM ballot will be issued in order to achieve such consensus.

TO: Sequence VG Mailing List

SUBJECT: 1. Revised Section 13.4.1
2. Report Forms and Data Dictionary Changes

On September 5, 2000, the Surveillance Panel approved a motion of Unanimous (or General) Consent to revise a number of items in the Sequence VG Test Procedure. These changes include:

1. Revised Section 13.4.1 to require that transformed results are to be rounded to four decimal places and that results are to be adjusted for laboratory bias in accordance with Appendix E of TMC Memorandum 94-200.

2. Revised the field length from 6.3 to 7.4 for the variables TRANOSCR, TOSCRCF, TOSCRCOR, and TOSCRFNL.

The attached pages reflect the addition/deletion of these items from the test procedure and are effective November 1, 2000.

Peter Misangyi
Product Engineering
Ford Motor Company

John L. Zalar
Administrator
ASTM Test Monitoring Center

Attachment

c: Lyle Bowman
Data Communications Committee Information Letter Mailing List

≥0.625 < 0.875	¾ A	≥24.00< 48.00	F
≥0.875 < 1.250	A	≥48.00< 96.00	G
≥1.250 < 1.750	AB	≥96.00< 192.0	H
≥1.750 < 2.500	B	≥192.0< 384.0	I
≥2.500 < 3.500	BC	≥384.0	J

13.2.2.2. *Flaky, Bubbly Sludge Deposits*--Since the occurrence of flaky, bubbly sludge deposits is thought to have a possible detrimental effect on long-term engine lubrication system performance, document the occurrence of this type of deposit in the Supplemental Operational Data section of the Final Test Report. Record the engine part(s) where this type of deposit was observed and the total percent of the surface area covered. Suggested wording is as follows: Approximately 6 % of the (left or right) rocker arm cover was found to exhibit flaky, bubbly sludge deposits.

13.3. *Varnish Ratings:*

13.3.1. *Preparation of Parts*--Rate the following parts for varnish deposits: piston skirts (8, thrust side only) and left and right rocker arm covers (RAC). Perform the varnish ratings after the sludge ratings are completed. The rating locations and dimensions shall conform with the locations and dimensions detailed on the rating worksheets (see A11). Avoid disturbing adjacent sludge deposits when the parts are being prepared for varnish ratings. Heavy sludge can be removed from a varnish rating area with a 25 mm rubber spatula prior to wiping. Wipe all parts firmly with wiping materials specified in CRC Manual No. 14. Firmly rub all wiping areas in the same direction until the surface is dry and free of sludge (until no more deposit is present on the wiping material after wiping).

13.3.2. *Average Varnish (Unweighted Average of three Parts)*--Use the procedure detailed as follows to determine the varnish rating of each part:

13.3.2.1. Rate any areas where varnish deposits have been altered during disassembly or sludge removal according to deposits on the surrounding non-altered areas. Do not rate altered areas as "*clean*".

13.3.2.2. Determine varnish ratings of all parts by comparison of the deposit on the rating location using the CRC Rust/Varnish/Lacquer Rating Scale for Non-rubbing Parts from CRC Manual 14.

13.4. *Clogging:*

13.4.1. *Oil Screen Clogging*—Determine the percentage of the total screen opening that is obstructed by sludge and debris. Transform the oil screen results by taking the natural log (ln) of the oil screen clogging plus 1 (ln(oil screen clogging+1). Round this value to four decimal places. Report both transformed and original results on the appropriate forms. Where laboratory bias is determined to be significant, adjust the results for laboratory severity in accordance with the procedure detailed in Appendix E of TMC Memorandum 94-200. Round this adjusted result to four decimal places and convert to original units by subtracting 1 from the antilog (e^X) of the adjusted result in transformed units. Record this value as the final result in original units on the appropriate form(s).

13.4.1.1. Flexible, transparent rating aids can be made for different surface areas so that when compared to the test screen's surface, a more accurate determination of surface clogging is possible.

13.4.1.2. If there is any question concerning whether the screen is covered with oil or sludge, blow lightly on the screen (see CRC Manual No. 12). Note an analysis of deposits identified as debris in the Supplemental Operational Data.

13.4.2. *PCV Valve Clogging*-Determine the percent clogging of the PCV valve according to the following procedure:

13.4.2.1. Measure the PCV valve flow rate at differential pressures of 25 and 60 kPa. Calculate the percent clogging in accordance with the following equation:

$$\text{PCV valve clogging, \%} = [(I - F) / I] \times 100$$

Where: I = initial flow rate,
and
F = final flow rate.

13.4.2.2. If there has been replacement of PCV valves during the test, calculate and report the PCV valve clogging for all of the PCV valves. Report the percent clogging of the last valve used on the Ratings and Measurements Page.

13.4.3 *Oil Ring Clogging*—Determine the percentage of slot clogging for each oil ring in accordance with the procedure detailed in CRC Manual No. 12. Calculate and record the average clogging for all eight rings

13.5. *Sticking:*

13.5.1. *Compression Rings*--Record the number of stuck compression rings. Definitions to classify the degree and type of sticking are detailed in Section 3. List both hot and cold stuck compression rings on the Test Results Summary page. Denote hot or cold stuck rings on the Supplemental Operational Data page and include the ring location (top or second) and the piston number.

13.6. *Used Oil Analyses:*

13.6.1. Perform the following analyses on the used oil samples taken every 24 h and on the final drain: Viscosity at 100°C and 40°C (Test Method D445), total base number (Test Method D4739), wear metal (Test Method D5185),and fuel dilution (Test Method D3525). Take samples at 0, 24, 48, 72, 96, 120, 144, 168, 192 and 216 h.

13.6.2. *Fuel Dilution*--Determine the fuel dilution, percent mass, by gas chromatography (see Test Method D 3525, with the following modifications) on the used oil samples.

13.6.2.1. Use C16 in place of C14 for the internal standard (1μL injector volume).

13.6.2.2. Presume that all components lighter than C16 are fuel.

13.6.2.3. The integrator should establish a horizontal baseline under the output curve until the leading edge of C16 is reached. Establish a second baseline extending horizontally

from the output curve, at the intersection of the output curve, and the leading edge of the C16 peak.

13.6.2.4. Column details are 305 cm x 3.2 mm (10 ft x 0.125 in.) SS; and the packing material is 5 % OV-1 on Chromosorb W HP.

13.6.2.5. Increase the oven temperature from 60 to 320°C, with the rate of change of temperature controlled at 8°C /min. Hold the temperature at 320°C for 16 min to elute oil.

13.6.3. *Pentane Insolubles*--Perform pentane insolubles. (Test Method D893, pentane only).on the used oil samples from h 0, 48, 96, 144, 192, 216.

13.7 Additional Measurements

13.7.1 *Follower Pin Wear*—Remove the pins from the cylinder 8 intake and exhaust roller followers. Using a surface profilometer, measure the longitudinal wear on the pin, to the nearest 0.1 μm. Average the results. Report results from both intake and exhaust followers.

13.7.2 Ring Gap Increase—Wash the compression rings from cylinders 1 and 8 with aliphatic naphtha and wipe clean with a dry cloth. Measure the ring in the master bore and calculate the ring gap increase. Compensate for any ring gap adjustments. Average the results of the four compression rings and record. Determine the maximum ring gap increase of the four compression rings and record.

13.7.3 *Bore Wear*—Measure cylinder 1 and 8 cylinder bores with the bearing caps in place. Clean the bores with a dry rag. The bores shall be clean and dry when measured. Use a bore gage micrometer to determine the diameter of cylinders 1 and 8 at the top, middle and bottom of the second ring travel in the transverse direction. Subtract these values from the initial measurement. Average the results and record. Determine the maximum bore wear result and record.

14. Assessment of Test Validity

14.1. *General*--The testing laboratory shall assess the validity of tests that have deviations from the procedure. The TMC and Test Sponsor shall assist the laboratory in the determination of calibration test validity, if requested by the laboratory. Use the following guidelines as a basis for determining test validity:

14.2. *Average Exhaust Gas NOx Levels*--The average NO_x level during a test should be within 600 ppm of the overall cumulative calibration test average for the laboratory. The cumulative calibration test average is the average NO_x level of the last ten calibration tests. Significantly lower NO_x levels could cause a reduction in sludge severity. For new laboratories, until ten reference oil tests are conducted, the average NOx level shall be between 3000 and 3900 ppm.

14.3. *Used Oil Analyses-Interpretation:*

14.3.1. *Iron and Aluminum Content*--The aluminum and iron content of the used oil samples can indicate the level of wear that occurs during a test. Increased camshaft bearing wear causes the aluminum content to increase. Increased camshaft, rocker arm, and cylinder bore wear causes

the iron content to increase. The rate of change in iron levels indicates the rate of change of wear levels, although wear tends to be linear throughout the test.

14.3.2. *Silicon Content*--Silicon content indicates the level of contamination of the oil from external sources and silicone-based gaskets. Silicone-based gaskets are used to seal the oil pan and rocker covers. Investigate the presence of silicone-based sealers, the cleanliness of engine parts during build-up, the cleanliness of the intake air, and the cleanliness of containers used for dispensing and sampling the oil if high levels of silicon are experienced.

14.3.3. *Fuel Dilution*--Fuel dilution indicates the degree to which the crankcase oil has been diluted with fuel. Fuel dilution of the crankcase oil is necessary to achieve adequate test severity. However, excessive fuel dilution can promote increased sludge severity and component wear. Investigate a higher level of fuel dilution than is normally noted.

14.4. *Blowby Flow Rate:*--The corrected average blowby flow rate during Stage II during the first 120 h of the test shall fall within the range from 60 to 70 L/min. Blowby should remain relatively constant throughout the entire test. Blowby typically drops slightly in the first 23 h of the test. Excursions below 60 L/min are acceptable as long as the average is between 60 and 70 L/min. If two consecutive Stage II readings within the first 120 h, are less than 56 L/min or the average is not within the prescribed limits, consider the test operationally invalid.

14.5. *Manifold Absolute Pressure (MAP)*--Throttle position is set by manifold absolute pressure during Stage I and II to account for the altitude of the laboratory, ambient barometric pressure, and the mechanical efficiency of the engine.

14.6. *Fuel Consumption Rate*--The fuel consumption rate should not exceed 9.0, 19.0 and 5.0 kg/hr for Stages I, II and III respectively.

14.7. *Oil Consumption*

14.7.1. Oil consumption should not occur early in the test. During this time period of the test, fuel dilution levels may increase oil levels above the test full mark. If the oil level is 200 g or more above the Test Full mark, then the engine, EEC system, fuel injectors, and so forth, should be checked for a malfunction that could be causing excessive fuel dilution.

14.7.2. The total amount of new oil added during the test shall not exceed 2000 g and no more than 400 g can be added at any 24 h oil leveling period.

14.8. *Engine Parts Replacement*--Parts that are rated to determine the final test results cannot be replaced during the test. The following parts can be replaced if necessary (record the circumstances involved in the replacement): ignition system components, EEC system and EPROM chip, PCV valve, seals and gaskets, valves or valve springs, fuel injectors, oil separator (PCV system) and spark plugs.

14.9. *Quality Index* --Requirements for quality index are listed in Annex A2. If the end of test quality index value is below 0.000 for reference oil tests, review the test operations with the TMC. The TMC will issue a letter to the laboratory and the test sponsor on its opinion. The laboratory will document its comments regarding end of test quality index values less than 0.000 for non-reference oil tests. The laboratory or test sponsor may request TMC review of test operations for non-reference oil tests. The TMC will issue a letter to document its opinion.

15. Final Test Report

15.1. *Report Format*--The various mandatory sections and specific details concerning the format of the report are outlined in this section. Examples of each section are shown in Annex A8. Deviations in the format are generally not permitted. However, deviations in nomenclature and other details may be permitted. Request for specific deviations shall be approved by the TMC and the Surveillance Panel. Reference Oil Test reports sent to the Test Monitoring Center can omit the photographs.

15.2. *Special Forms for Automated Data Acquisition*--Forms for automated data acquisition systems shall be approved by the TMC and Surveillance Panel.

15.3. *Standard Report*--Include the following sections in the standard test report. Begin each section on a new page, and insert the sections in the following order:

15.3.1. Test Report cover (includes test validity statement-see Annex A7.1)

15.3.2. Table of Contents (Annex A7.2)

15.3.3. Summary of Test Method (Annex A7.3)

15.3.4. Test Results Summary (Annex A7.4)

15.3.5. Rating and Measurement Summary (Annex A7.5)

15.3.6. Operational Summary (Annex A7.6)

15.3.7. Oil Addition and Blowby Rates (Annex A7.7)

15.3.8. Analysis of Oil (Annex A7.8)

15.3.9. Downtime Occurrences and Other Comments (Annex A7.9)

Photographs (see 15.4)

15.4. *Photographs*--The required photographs are listed in this section. All photographs shall be 5 by 7 in., and in full color. The following photographs are required:

15.4.1. RAC and camshaft baffles

15.4.2. Oil pan and baffle

15.4.3. Oil pick-up screen

15.4.4. Cylinder head valve decks

15.4.5. Timing chain cover

15.4.6. Average and worst piston skirts, thrust sides

16. Precision and Bias

16.1 Test Precision—Reference Oils

16.1.1.1 *Intermediate Precision (ip) (formerly called repeatability)*—in Table 7 is the difference between two results obtained on the same test oil in the same laboratory and would, in the long run, in the normal and correct conduct of the test method, exceed the values shown in only one case in twenty. It should be noted that these repeat tests are not run in the same engines; that each engine is completely rebuilt before each test, and the engine is believed to be an important variable affecting the precision of the test.

16.1.2 *Reproducibility (R)*—The difference between two single and independent results obtained on the same oil by different operators working in different laboratories and would, in the long run, in the normal and correct conduct of the test method, exceed the values in Table 7 only one case in twenty.

16.2 Bias—Bias will be determined by applying an accepted statistical technique to reference oil test results, and when a significant bias is determined, a severity adjustment will be permitted for non-reference oil test results

Table 7 Reference Oil Statistics[A]

Variable, Merits	Intermediate Precision[B]		Reproducibility[C]	
	S_{ip}[D]	ip[E]	S_R[D]	R[E]
Average Engine Sludge	0.63	1.76	0.64	1.79
Rocker Cover Sludge	0.32	0.90	0.35	0.98
Average Engine Varnish	0.10	0.28	0.10	0.28
Oil Screen Clogging, Sludge	17.32	48.50	17.26	48.33
Average Piston Varnish	0.27	0.76	0.30	0.84

A These statistics are based on results obtained on Test Monitoring Center Reference Oils 925-2, 926-1, 930, 1006 and 1007 over the period from June 1, 1999 through August 26, 1999.
B Intermediate Precision Values refer to tests run on the same oil in the same laboratory.
C Reproducibility Values refer to tests run on the same oil in different laboratories.
D s = standard deviation.
E On the basis of test error alone, the difference, in absolute value, between two test results will be expected to exceed this value about 5% of the time. This value is obtained by multiplying the standard deviation by 2.8.

17. Keywords

17.1. lubricating oils; Sequence VG; sludge and varnish; spark-ignition automotive engine; stop-and-go service

VG REPORT FORMS VERSION *20000831*

REPORT ON SEQUENCE VG EVALUATION

CONDUCTED FOR

	V = VALID
	I = INVALID
	N = RESULTS CAN NOT BE INTERPRETED AS REPRESENTATIVE OF OIL PERFORMANCE (NON-REFERENCE OIL) AND SHALL NOT BE USED IN DETERMINING AN AVERAGE TEST RESULT USING MULTIPLE TEST ACCEPTANCE CRITERIA.

	NR = Non-reference Oil Test
	RO = Reference Oil Test

Test Number			
Test Stand:	Runs Between Calibration Tests:	Total Runs on Test Stand:	
Date Completed:		End of Test Time:	
Oil Code:			
Formulation/Stand Code:			
Alternate Codes:			

In my opinion this test been conducted in a valid manner in accordance with the VG Test Procedure (RR:) and the appropriate amendments through the Information Letter system. The remarks included in the report describe the anomalies associated with this test.

SUBMITTED BY:

_____
Testing Laboratory

_____
Signature

_____
Typed Name

_____
Title

FIG A7.1 Title Page

Data Dictionary

Sequence	Form	Test Area	Field Name	Field Length	Decimal Size	Data Type	Units/Format	Description
10	1	VG	VERSION	8	0	C	YYYYMMDD	VG VERSION 20000831
20	1	VG	TSTSPON1	40	0	C		CONDUCTED FOR, FIRST LINE
30	1	VG	TSTSPON2	40	0	C		CONDUCTED FOR, SECOND LINE
40	1	VG	LABVALID	1	0	C	V, I OR N	TEST LAB VALIDATION (V, I OR N)
50	1	VG	TSTOIL	2	0	C	NR or RO	OIL TEST TYPE (NR or RO)
60	1	VG	STAND	5	0	C		STAND
70	1	VG	STRUN	4	0	C		RUNS BETWEEN CALIBRATION TESTS
80	1	VG	TOTSRUN	5	0	C		TOTAL RUNS-TEST STAND
90	1	VG	DTCOMP	8	0	C	YYYYMMDD	DATE COMPLETED (YYYYMMDD)
100	1	VG	EOTTIME	5	0	C	HH:MM	TIME COMPLETED (HH:MM)
110	1	VG	OILCODE	38	0	C		TEST OIL CODE
120	1	VG	FORM	38	0	C		FORMULATION/STAND CODE
130	1	VG	ALTCODE1	10	0	C		ADDITIONAL LABORATORY CODE 1
140	1	VG	ALTCODE2	10	0	C		ADDITIONAL LABORATORY CODE 2
150	1	VG	ALTCODE3	10	0	C		ADDITIONAL LABORATORY CODE 3
160	1	VG	OPVALID	8	0	C	HAS/HAS NOT	OPERATIONAL VALIDITY STATEMENT (HAS/HAS NOT)
170	1	VG	SUBLAB	40	0	C		SUBMITTED BY: TESTING LABORATORY
180	1	VG	SUBSIGIM	40	0	C		SUBMITTED BY: SIGNATURE IMAGE
190	1	VG	SUBNAME	40	0	C		SUBMITTED BY: SIGNATURE TYPED NAME
200	1	VG	SUBTITLE	40	0	C		SUBMITTED BY: TITLE
210	4	VG	LAB	2	0	C		LAB CODE
220	4	VG	DTSTRT	8	0	C	YYYYMMDD	START DATE (YYYYMMDD)
230	4	VG	STRTTIME	5	0	C	HH:MM	START TIME (HH:MM)
240	4	VG	ENGINE	6	0	C		ENGINE
250	4	VG	SAEVISC	7	0	C		SAE VISCOSITY GRADE
260	4	VG	TESTLEN	3	0	Z	HHH	TEST LENGTH (HHH)
270	4	VG	FUELBTID	8	0	C		FUEL BATCH IDENTIFIER
280	4	VG	IND	6	0	C		TMC OIL CODE
290	4	VG	AES	6	2	N	MERITS	AVG ENGINE SLUDGE RATING (MERITS)
300	4	VG	RACS	6	2	N	MERITS	AVG ROCKER COVER SLUDGE RATING (MERITS)
310	4	VG	AEV3	6	2	N	MERITS	AVG ENGINE VARNISH 3-PART RATING (MERITS)
320	4	VG	APV	6	2	N	MERITS	AVG PISTON SKIRT RATING (MERITS)
330	4	VG	OSCRNSLG	4	0	N	% AREA	OIL SCREEN SLUDGE CLOGGING (% AREA)
340	4	VG	NHSCMPRG	2	0	N		NUMBER HOT STUCK COMPRESSION RINGS
350	4	VG	TRANOSCR	7	4	N	Trans Units	TRANSFORMED OIL SCREEN SLUDGE (Trans Units)
360	4	VG	AESCF	6	2	N	MERITS	AVERAGE ENGINE SLUDGE CORRECTION FACTOR (MERITS)
370	4	VG	RACSCF	6	2	N	MERITS	AVERAGE ROCKER COVER SLUDGE CORRECTION FACTOR (MERITS)
380	4	VG	AEV3CF	6	2	N	MERITS	AVERAGE ENGINE VARNISH 3-PART CORRECTION FACTOR (MERITS)
390	4	VG	APVCF	6	2	N	MERITS	AVERAGE PISTON SKIRT VARNISH CORRECTION FACTOR (MERITS)
400	4	VG	TOSCRCF	7	4	N	TRANS UNITS	OIL SCREEN SLUDGE CORRECTION FACTOR (TRANS UNITS)
410	4	VG	NHSRCF	2	0	N		NUMBER OF HOT STUCK RINGS CORRECTION FACTOR
420	4	VG	TOSCRCOR	7	4	N	TRANS UNITS	TRANSFORMED OIL SCREEN SLUDGE CORRECTED RESULT (TRANS UNITS)
430	4	VG	AESSA	6	2	N	MERITS	AVERAGE ENGINE SLUDGE SEVERITY ADJUSTMENT (MERITS)
440	4	VG	RACSSA	6	2	N	MERITS	AVERAGE ROCKER COVER SLUDGE SEVERITY ADJUSTMENT (MERITS)
450	4	VG	AEV3SA	6	2	N	MERITS	AVERAGE ENGINE VARNISH 3-PART SEVERITY ADJUSTMENT (MERITS)
460	4	VG	APVSA	6	2	N	MERITS	AVERAGE PISTON SKIRT VARNISH SEVERITY ADJUSTMENT (MERITS)
470	4	VG	TOSCRSA	7	4	N	TRANS UNITS	OIL SCREEN SLUDGE SEVERITY ADJUSTMENT (TRANS UNITS)
480	4	VG	NHSRSA	2	0	N		NUMBER OF HOT STUCK RINGS SEVERITY ADJUSTMENT
490	4	VG	TOSCRFNL	7	4	N	TRANS UNITS	TRANSFORMED OIL SLUDGE SCREEN FINAL RESULT (TRANS UNITS)
500	4	VG	AESFNL	6	2	N	MERITS	AVERAGE ENGINE SLUDGE FINAL RESULT (MERITS)
510	4	VG	RACSFNL	6	2	N	MERITS	AVG ROCKER COVER SLUDGE FINAL RESULT (MERITS)
520	4	VG	AEV3FNL	6	2	N	MERITS	AVERAGE ENGINE VARNISH 3-PART FINAL RESULT (MERITS)
530	4	VG	APVFNL	6	2	N	MERITS	AVERAGE PISTON SKIRT VARNISH FINAL RESULT (MERITS)

Fig. A12.1 Data Dictionary