

Multicylinder Test Sequences for Evaluating Automotive Engine Oils

Part 1:
Sequence 11D

STP 315H

PART 1

04-315081-12



AMERICAN SOCIETY FOR TESTING AND MATERIALS

MULTICYLINDER TEST SEQUENCES FOR EVALUATING AUTOMOTIVE ENGINE OILS

Part 1: Sequence IID

Sponsored by
Section I on Engine Oils
Technical Division B on Automotive Lubricants
ASTM Committee D-2 on Petroleum
Products and Lubricants

ASTM SPECIAL TECHNICAL PUBLICATION 315H (PART 1)

04-315081-12



AMERICAN SOCIETY FOR TESTING AND MATERIALS
1916 Race Street, Philadelphia, Pa. 19103

Copyright © by AMERICAN SOCIETY FOR TESTING AND MATERIALS 1980
Library of Congress Catalog Card Number: 80-68369

NOTE

The Society is not responsible, as a body,
for the statements and opinions
advanced in this publication.

Printed in Philadelphia, Pa.
September 1980

AMERICAN SOCIETY FOR TESTING AND MATERIALS
SPECIAL TECHNICAL PUBLICATION
STP-315H

PART I
SEQUENCE IID

**Multicylinder Test Sequences
For Evaluating Automotive Engine Oils**

September 15, 1979

Related ASTM Publications

Shear Stability of Multigrade Crankcase Oil, DS 49 (1973), \$7.75, 05-049000-12

Shear Stability of Multigrade Oils—IP Fleet Test, DS 49-S1 (1974), \$4.00, 05-0490001-12

Low-Temperature Pumpability Characteristics of Engine Oils in Full-Scale Engines, DS 57 (1975), \$16.00, 05-570000-12

Significance of ASTM Tests for Petroleum Products, STP 7C (1977), \$11.75, 04-007030-12

The Relationship Between Engine Oil Viscosity and Engine Performance, Part I, STP 621 (1977), \$15.00, 04-621000-12

The Relationship Between Engine Oil Viscosity and Engine Performance, Part II, STP 621-S1 (1977), \$12.00, 04-621010-12

The Relationship Between Engine Oil Viscosity and Engine Performance, Part III, STP 621-S2 (1978), \$15.00, 04-621030-12

The Relationship Between Engine Oil Viscosity and Engine Performance, Parts IV and V, STP 621-S4 (1980), \$18.00, 04-621040-12

FOREWORD

The test method described in this publication has not been subjected to the ASTM Standardization Procedure. It is not a standard or standard recommended practice of the American Society of Testing and Materials.

The test sequences for evaluating automotive engine oils were prepared to make available a technical language to describe quantitatively the operating conditions for determining the performance of crankcase oils and to describe the oil properties needed for satisfactory performance in modern passenger cars and light trucks.

One of the most important uses of the test sequences is the technical description of various classifications of oils according to performance and type of service (accomplished by cooperative action of committees in SAE, API, and ASTM). Details of the classifications are published in SAE Information Report "Engine Oil Performance and Engine Service Classification — SAE J183," API Publication 1509 "Engine Service Classification and Guide to Crankcase Oil Selection," and ASTM Research Report D-2:1002 "Engine Oil Performance Classifications."

The multi-cylinder test sequences were originally developed in 1956 by Section G-IV, a Special Study Group on Application of Crankcase Oils, under Technical Division B on Lubricating Oils, of ASTM Committee D-2 on Petroleum Products and Lubricants. Intended as the technical language for evaluating and defining oils for API Service MS, they have been known previously as the "G-IV Test Sequences" and as the "MS Test Sequences." Since 1971, the Sequence Tests have been used to define the performance requirements of the jointly developed ASTM, API, and SAE Engine Oil Classification System.

A reorganization of Technical Division B resulted in the assignment of responsibility for this language to Section I on Engine Oils of Technical Division B of Committee D-2. In 1962, Section I recommended that the Sequences be made available as an ASTM Special Technical Publication (STP). From that time until the completion of the eighth revision such STP's were published only in bound copies containing all three test sequences. However, this, the ninth revision, represents a modification to that practice. This printing represents the first time that the Sequence IID, IIID and V-D are being printed in three separate STP's. ASTM STP 315H (Part 1) contains the Sequence IID Procedure; ASTM STP 315H (Part 2) contains the Sequence IIID Procedure, and STP 315H (Part 3), when published, will contain the Sequence V-D Procedure. Each of these procedures will be available in either bound copies or three-hole punched pre-prints for insertion into loose-leaf binders.

Information is included showing the precision data and correlation of the specific test sequence with field and previous test experience as available at the time of this printing. As a continuing activity, the appropriate Surveillance Panel of Section I gathers and periodically reports new correlation and precision data. Latest reports are available on request to the chairman of Section I. In this publication, the Sequence IID Test Procedure is presented in detail.

In accordance with the policy of keeping the test language timely and useful, the current publication incorporates changes resulting from experience with the test. Many of these changes for Sequence IID have been discussed in Information Letters. Purchasers

of STP 315H desiring to receive Information Letters published subsequent to this printing may do so by writing to:

ASTM Test Monitoring Center
4400 Fifth Avenue
Pittsburgh, Pennsylvania 15213
Attention: P. A. Bennett

This ninth version was edited by Concept Engineering, Inc., (P. O. Box 29265, San Antonio, Texas 78229), the test developers, and the ASTM Sequence IID Surveillance Panel.

TABLE OF CONTENTS

1.	SCOPE	1
2.	SUMMARY OF METHOD	3
3.	SIGNIFICANCE	5
3.1	Method	5
3.2	Deposit Ratings	5
3.3	Other Ratings	5
3.4	Use	5
3.5	Validity	5
3.6	Laboratory Engine Test Calibration	5
3.6.1	Reporting of Reference Results	6
3.6.2	Analysis of Reference Oils	7
3.7	Performance Characteristics of Motor Oils	8
3.7.1	Field Correlation	8
3.7.2	Precision Data	8
3.7.2.1	Reference Oil Data	8
3.7.2.2	Commercial Oil Data	8
4.	APPARATUS	13
4.1	Test Engine Configuration	13
4.2	Engine Speed and Load Control	13
4.3	Laboratory Ambient Conditions	13
4.4	Engine Cooling System	14
4.5	Flushing Tank	14
4.6	Coolant Mixing Tank	14
4.7	Jacketed Rocker Cover, Intake Manifold Crossover and Breather Tube Cooling Systems	14
4.8	External Oil Cooling System	15
4.9	Fuel System	15
4.10	Carburetor Air Supply Humidity	16
4.11	Temperature Measurement	16
4.11.1	Thermocouple Location	17
4.11.1.1	Oil Filter Block	17
4.11.1.2	Oil Pan (Sump)	17
4.11.1.3	Engine Coolant Out	17

4.11.1.4	Engine Coolant In	17
4.11.1.5	Rocker Cover Coolant Out	17
4.11.1.6	Breather Tube Coolant Out	17
4.11.1.7	Blowby Gas	17
4.11.1.8	Intake Manifold Exhaust Crossover Coolant Outlet	17
4.11.1.9	Carburetor Air	18
4.11.1.10	Intake Manifold Mixture	18
4.11.1.11	Fuel.	18
4.12	AFR Determination	18
4.12.1	Optional Determinations	18
4.13	Exhaust and Exhaust Back Pressure System	18
4.13.1	Exhaust Pipes	18
4.13.2	Exhaust Back Pressure Control System.	18
4.13.3	Exhaust Sample Lines	19
4.14	Blowby Meter	19
4.15	Pressure Measurement and Pressure Sensor Location	19
4.15.1	Crankcase Pressure	19
4.15.2	Oil Pump Outlet Pressure	19
4.15.3	Engine Oil Filter Pressure	19
4.15.4	Carburetor Inlet Air Pressure.	20
4.15.5	Intake Manifold Vacuum	20
4.15.6	Exhaust Back Pressure.	20
4.15.7	Rocker Cover Coolant Pressure	20
4.15.8	Breather Tube Coolant Pressure.	20
4.15.9	Intake Manifold Exhaust Crossover Coolant Outlet Pressure	20
5.	REAGENTS AND MATERIALS	21
5.1	Test Oil	21
5.2	Test Fuel	21
5.3	Engine Coolant	21
5.3.1	Engine Coolant Additive Concentrate	21
5.3.2	Glycol Coolant Preparation.	22
5.3.3	Coolant Calibration Standards	22
5.4	Cleaning Materials	23

5.4.1	Organic Solvent	23
5.4.2	Rust Remover	23
5.4.3	General Cleaning Agents	23
5.5	Sealing Compounds	23
6.	PREPARATION OF APPARATUS	25
6.1	Dipstick Calibration	25
6.2	External Oil Cooling System and Heat Exchanger Cleaning	25
6.3	Jacketed Rocker Cover Cleaning	26
6.4	Breather Tube Cleaning	26
6.5	Intake Manifold Cleaning	26
7.	ENGINE PREPARATION	29
7.1	Cleaning of Engine Parts	29
7.2	Engine Buildup Procedure	29
7.2.1	General Information	29
7.2.1.1	Sealing Compound Applications	30
7.2.2	Fastener Torque Specification and Torqueing Procedures	30
7.2.2.1	Cylinder Head Bolts	30
7.2.2.2	Intake Manifold Bolts	31
7.2.2.3	Miscellaneous	31
7.2.3	Parts Replacement	31
7.2.3.1	New Parts Required Each Test	31
7.2.3.2	Parts Replaced as Necessary	32
7.2.4	Cylinder Block Preparation	33
7.2.4.1	Modifications	33
7.2.4.1.1	Camshaft Thrust Surface	33
7.2.4.1.2	Oil Gallery Plug	33
7.2.4.1.3	Engine Block Freeze Plugs	33
7.2.4.1.4	Deburring of Block	33
7.2.4.1.5	Oil Filler Tube	33
7.2.4.2	Honing Equipment	33
7.2.4.3	Pre-Stressing of Block	34
7.2.4.4	Honing Procedure and Surface Finish	34

7.2.5	Piston Fitting and Numbering	34
7.2.6	Piston Ring Fitting	35
7.2.7	Main Bearings	35
7.2.8	Connecting Rod Bearings.	35
7.2.9	Camshaft Bearings	36
7.2.10	Camshaft	36
	7.2.10.1 Camshaft Thrust Washer	36
7.2.11	Camshaft Sprocket and Chain.	36
7.2.12	Camshaft Gear Bolt	36
7.2.13	Timing Gear Oil Deflector and Washer	36
7.2.14	Harmonic Balancer and Oil Slinger	36
7.2.15	Engine Front Cover and Seal	36
7.2.16	Timing Mark Indicator	37
7.2.17	Oil Pump	37
	7.2.17.1 Oil Pump Screen	37
	7.2.17.2 Oil Pump Relief Valve	37
	7.2.17.3 Oil Pump Relief Valve Spring	37
7.2.18	Dipstick Tube	37
7.2.19	Oil Pan	37
7.2.20	Cylinder Head Preparation	37
	7.2.20.1 Cylinder Head Freeze Plugs	37
	7.2.20.2 Deburring of Cylinder Head	38
	7.2.20.3 Machining of Valve Guides	38
	7.2.20.4 Valve Lapping	38
	7.2.20.5 Valve Stem Seals	38
	7.2.20.6 Cylinder Head Cleaning	38
	7.2.20.7 Valve Springs	38
7.2.21	Stud-Type Head Bolts and Rocker Cover Deflectors.	39
7.2.22	Hydraulic Valve Lifters	39
7.2.23	Pushrods.	39
7.2.24	Intake Manifold.	39
	7.2.24.1 Modifications.	39

7.2.24.2	Choke Stove	39
7.2.24.3	Deburring of Intake Manifold	39
7.2.24.4	Gaskets	39
7.2.25	Rocker Cover Spacers and Gaskets	39
7.2.26	Water Inlet Adapter	40
7.2.27	Breather Tube	40
7.2.28	Thermostat Housing	40
7.2.29	Fuel Pump and Eccentric.	40
7.2.30	Oil Filter Housing.	40
7.2.31	Oil Sample Line.	40
7.2.32	Ignition System	40
7.2.32.1	High Energy Ignition (H.E.I.) Wire	40
7.2.32.2	Distributor Advance.	40
7.2.32.3	Vacuum Advance Unit	41
7.2.32.4	Spark Plugs	41
7.2.33	Carburetor	41
7.2.34	Accessory Drive Units	41
7.2.35	Special Parts	41
7.2.36	Exhaust Manifolds.	42
7.2.37	Engine Flywheel and Guards	42
7.2.38	Pressure Checking of Engine Coolant System	42
7.2.39	Lifting of Assembled Engines	42
7.2.40	Engine Mounts	43
7.2.41	Drive Shaft	43
8.	TEST PROCEDURE	45
8.1	External Cooling System Cleaning	45
8.2	Engine Coolant Jacket Cleaning (Flushing)	45
8.2.1	Plumbing Connections	45
8.2.2	Procedure	45
8.3	Coolant Charging	47
8.4	Test Oil Charging	47
8.5	Installation of Rocker Covers.	48
8.6	Engine Startup and Shutdown Procedures	48
8.6.1	Startup	48
8.6.2	Shutdown	48

8.7	Timing Run	48
8.8	Oil Sampling	49
	8.8.1 Checks for Glycol Contamination	49
8.9	Chilled Glycol Coolant Addition.	50
8.10	Oil Leveling	50
8.11	Operations	50
	8.11.1 Test Time	50
	8.11.2 Non-Scheduled Shutdowns	50
	8.11.3 Dipstick and Guide Tube	50
	8.11.4 Oil Fill Tube	50
	8.11.5 Blowby Measurement	53
	8.11.6 Glycol/Water Additions	53
	8.11.7 Carburetor Adjustments for AFR Control	53
	8.11.8 Carburetor Air Inlet Adapter	54
	8.11.9 Data Recording	54
	8.11.10 Stage I (28 Hours).	59
	8.11.11 Stage II (2 Hours)	60
	8.11.12 Stage III (2 Hours).	61
9.	FINAL INSPECTION AND REPORTING	63
9.1	Engine Teardown and Elapsed Time	63
	9.1.1 Disassembly and Preparation of Parts for Rating	63
9.2	Rust Rating	63
	9.2.1 Environment	63
	9.2.2 Parts Layout	63
	9.2.3 Method	64
9.3	Photographs of Test Parts	64
9.4	Permanent Storage of Test Parts	64
	9.4.1 Desiccator Storage	64
	9.4.2 Strippable Coatings	64
9.5	Reporting of Results	66
	9.5.1 Report Forms	66
	9.5.2 Calculation of Rust Results	66
	9.5.3 Lifter Plunger Sticking	66
	9.5.4 Oil Pump Relief Valve Sticking	66

9.5.5	Oil Consumption Computation	70
9.5.6	Operational Test Parameters and Deviations	70
9.6	Review of Representative Rust Parts	70
10.	GENERAL INFORMATION	71
10.1	Safety	71
10.2	Glossary of Definitions	73
10.3	Glossary of Symbols and Terms	74
10.4	Document Precision Information	75

LIST OF FIGURES

<u>No.</u>	<u>Description</u>	<u>Page No.</u>
1.	Correlation of Sequence IID and Short-Trip Results	9
2.	Reference Oil Precision Data	10
3.	Commercial Oil Precision Data	11
4.	Sequence IID Operational Check List and Oil Level Instructions	51
5.	Sequence IID Oil Sample, Level and Consumption Records Sheet	52
6.	Sequence IID Air to Fuel Ratio Chart	55
7.	Sequence IID Daily Log	57
8.	Sequence IID Supplemental Daily Log	58
9.	Sequence IID Rust Rating Worksheet.	65
10.	Sequence IID Test Results	67
11.	Sequence IID Reference Test Results	68
12.	Sequence IID Operational Summary	69

APPENDICES

Appendix A PROCUREMENT OF TEST MATERIALS

<u>Section</u>	<u>Item</u>	<u>Page No.</u>
A.1	General Communications Concerning Sequence IID Reference Tests	77
A.2	General Communications Concerning Sequence IID Questions and Candidate Tests	77
A.3	Reference Oils	77
A.4	Test Engines	77
A.5	Special Sequence Test Parts	78
A.6	External Oil Pump	78
A.7	External Oil System Heat Exchanger.	78
A.8	External Oil System and Other Quick Disconnect Fittings	78
A.9	Fuel Pressure Regulator	78
A.10	Fuel Shut-off Valve	78
A.11	Humidity Measuring Equipment	79
A.12	Thermocouples and Packing Glands	79
A.13	Exhaust Pipes	79
A.14	Crankcase Pressure Gauge (Magnehelic)	79
A.15	Test Fuel	79
A.16	Glycol	79
A.17	Sodium Metaborate	79
A.18	NACAP	80
A.19	Calcium Nitrate	80
A.20	Sodium Nitrite	80
A.21	Pluronic L-61	80
A.22	Decyl Alcohol	80
A.23	Coolant Hydrometer.	80
A.24	Solvent S-26	80
A.25	Oakite 77, Oakite II, Oakite Rust Stripper, Oakite Drycid	81
A.26	Sovasol #5	81
A.27	Perfect Seal No. 4 Sealing Compound	81

A.28	Permatex, No. 2 Non-Hardening and Permatex 6BR	81
A.29	3M Super Weatherstrip Adhesive	81
A.30	Anti-Seizure Compound	81
A.31	3M Cloth	82
A.32	Breather Tube Gaskets.	82
A.33	SAE 10W Mineral Oil (EF411)	82
A.34	Desiccator for Paint Roller.	82
A.35	Intake and Exhaust Manifold Gaskets	82
A.36	Piston Rings	83
A.37	Pistons	83
A.38	Valve Lifters	83
A.39	Valve Stem Seals	83
A.40	Rocker Cover Gaskets	83
A.41	Valve Springs.	84
A.42	Cylinder Hone	84
A.43	Ring Gap Feeler Gauge	84
A.44	Ring Grinder	84
A.45	Cam Bearing Installation Tool	84
A.46	Valve Guide Cutter for Valve Stem Seals	84
A.47	Spark Plug Wire Removal Tool	85
A.48	Driveshaft	85
A.49	Teri-Towels	85
A.50	Rating Lights.	85
A.51	CRC Rating Manual	85
A.52	Strippable Coating	85

Appendix B PRINT LISTINGS

<u>Section</u>	<u>Item</u>	<u>Page No.</u>
B.1	Numerical	87
B.2	Alphabetical	92