

# **Multicylinder Test Sequences for Evaluating Automotive Engine Oils**

**Part 2:**  
Sequence 111D

**STP 315H**

**PART 2**

04-315090-12



AMERICAN SOCIETY FOR TESTING AND MATERIALS

# MULTICYLINDER TEST SEQUENCES FOR EVALUATING AUTOMOTIVE ENGINE OILS

## Part 2: Sequence IIID

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 2)

04-315090-12



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 2**  
**SEQUENCE IIID**

**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 IIID 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 IIID 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 IIID Surveillance Panel.

## TABLE OF CONTENTS

|           |                                                                                                 |           |
|-----------|-------------------------------------------------------------------------------------------------|-----------|
| <b>1.</b> | <b>SCOPE . . . . .</b>                                                                          | <b>1</b>  |
| <b>2.</b> | <b>SUMMARY OF METHOD . . . . .</b>                                                              | <b>3</b>  |
| <b>3.</b> | <b>SIGNIFICANCE . . . . .</b>                                                                   | <b>5</b>  |
| 3.1       | Method . . . . .                                                                                | 5         |
| 3.2       | Viscosity Increase . . . . .                                                                    | 5         |
| 3.3       | Deposit and 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     | Correlation Data . . . . .                                                                      | 8         |
| 3.7.2     | Precision Data . . . . .                                                                        | 8         |
| 3.7.2.1   | Reference Oil Data . . . . .                                                                    | 8         |
| 3.7.2.2   | Commercial Oil Data . . . . .                                                                   | 8         |
| <b>4.</b> | <b>APPARATUS . . . . .</b>                                                                      | <b>13</b> |
| 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 . . . . .                                                                 | 13        |
| 4.5       | Flushing Tank . . . . .                                                                         | 14        |
| 4.6       | Coolant Mixing Tank . . . . .                                                                   | 14        |
| 4.7       | Jacketed Rocker Cover, Intake Manifold Crossover<br>and Breather Tube Cooling Systems . . . . . | 14        |
| 4.8       | External Oil Cooling System . . . . .                                                           | 15        |
| 4.9       | Fuel System . . . . .                                                                           | 16        |
| 4.10      | Carburetor Air Supply Humidity . . . . .                                                        | 16        |
| 4.11      | Temperature Measurement . . . . .                                                               | 17        |
| 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 . . . . .                                                                    | 18        |

|           |                                                                        |           |
|-----------|------------------------------------------------------------------------|-----------|
| 4.11.1.4  | Engine Coolant In . . . . .                                            | 18        |
| 4.11.1.5  | Rocker Cover Coolant Out . . . . .                                     | 18        |
| 4.11.1.6  | Breather Tube Coolant Out . . . . .                                    | 18        |
| 4.11.1.7  | Blowby Gas . . . . .                                                   | 18        |
| 4.11.1.8  | Intake Manifold Exhaust Crossover<br>Coolant Outlet . . . . .          | 18        |
| 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 . . . . .                                      | 19        |
| 4.13      | Exhaust and Exhaust Back Pressure Systems . . . . .                    | 19        |
| 4.13.1    | Exhaust Pipes . . . . .                                                | 19        |
| 4.13.2    | Exhaust Back Pressure Control System . . . . .                         | 19        |
| 4.13.3    | Exhaust Sample Lines . . . . .                                         | 19        |
| 4.14      | Blowby Meter . . . . .                                                 | 19        |
| 4.15      | Pressure Measurement and Pressor Sensor Location . . . . .             | 20        |
| 4.15.1    | Crankcase Pressure . . . . .                                           | 20        |
| 4.15.2    | Oil Pump Outlet Pressure . . . . .                                     | 20        |
| 4.15.3    | Engine Oil Filter Pressure . . . . .                                   | 20        |
| 4.15.4    | Carburetor Inlet Air Pressure . . . . .                                | 20        |
| 4.15.5    | Intake Manifold Vacuum . . . . .                                       | 20        |
| 4.15.6    | Exhaust Back Pressure . . . . .                                        | 21        |
| 4.15.7    | Rocker Cover Coolant Pressure . . . . .                                | 21        |
| 4.15.8    | Breather Tube Coolant Pressure . . . . .                               | 21        |
| 4.15.9    | Intake Manifold Exhaust Crossover<br>Coolant Outlet Pressure . . . . . | 21        |
| 5.        | <b>REAGENTS . . . . .</b>                                              | <b>23</b> |
| 5.1       | Test Oil . . . . .                                                     | 23        |
| 5.2       | Test Fuel . . . . .                                                    | 23        |
| 5.3       | Engine Coolant . . . . .                                               | 23        |
| 5.3.1     | Engine Coolant Additive Concentrate . . . . .                          | 23        |
| 5.3.2     | Glycol Coolant Preparation . . . . .                                   | 24        |
| 5.4       | Cleaning Materials . . . . .                                           | 24        |
| 5.4.1     | Organic Solvent . . . . .                                              | 24        |
| 5.4.2     | General Cleaning Agents . . . . .                                      | 24        |

|           |                                                                     |           |
|-----------|---------------------------------------------------------------------|-----------|
| 5.5       | Sealing Compounds . . . . .                                         | 25        |
| <b>6.</b> | <b>PREPARATION OF APPARATUS . . . . .</b>                           | <b>27</b> |
| 6.1       | Dipstick Calibration . . . . .                                      | 27        |
| 6.2       | External Oil Cooling System and Heat Exchanger Cleaning . . . .     | 27        |
| 6.3       | Jacketed Rocker Cover Cleaning . . . . .                            | 28        |
| 6.4       | Breather Tube Cleaning . . . . .                                    | 28        |
| 6.5       | Intake Manifold Cleaning . . . . .                                  | 28        |
| <b>7.</b> | <b>ENGINE PREPARATION . . . . .</b>                                 | <b>31</b> |
| 7.1       | Cleaning of Engine Parts . . . . .                                  | 31        |
| 7.2       | Engine Buildup Procedure . . . . .                                  | 31        |
| 7.2.1     | General Information . . . . .                                       | 31        |
| 7.2.1.1   | Sealing Compound Applications . . . . .                             | 32        |
| 7.2.2     | Fastener Torque Specification<br>and Torqueing Procedures . . . . . | 32        |
| 7.2.2.1   | Cylinder Head Bolts . . . . .                                       | 32        |
| 7.2.2.2   | Intake Manifold Bolts . . . . .                                     | 33        |
| 7.2.2.3   | Miscellaneous . . . . .                                             | 33        |
| 7.2.3     | Parts Replacement . . . . .                                         | 33        |
| 7.2.3.1   | New Parts Required Each Test . . . . .                              | 33        |
| 7.2.3.2   | Parts Replaced as Necessary . . . . .                               | 34        |
| 7.2.4     | Cylinder Block Preparation . . . . .                                | 35        |
| 7.2.4.1   | Modifications . . . . .                                             | 35        |
| 7.2.4.1.1 | Camshaft Thrust<br>Surface . . . . .                                | 35        |
| 7.2.4.1.2 | Oil Gallery Plug . . . . .                                          | 35        |
| 7.2.4.1.3 | Engine Block<br>Freeze Plugs . . . . .                              | 35        |
| 7.2.4.1.4 | Deburring of Block . . . . .                                        | 35        |
| 7.2.4.1.5 | Oil Filler Tube . . . . .                                           | 35        |
| 7.2.4.2   | Honing Equipment . . . . .                                          | 35        |
| 7.2.4.3   | Pre-Stressing of Block . . . . .                                    | 36        |
| 7.2.4.4   | Honing Procedure<br>and Surface Finish . . . . .                    | 36        |
| 7.2.5     | Piston Fitting and Numbering . . . . .                              | 36        |
| 7.2.6     | Piston Ring Fitting . . . . .                                       | 37        |
| 7.2.7     | Main Bearings . . . . .                                             | 37        |

|          |                                                              |    |
|----------|--------------------------------------------------------------|----|
| 7.2.8    | Connecting Rod Bearings. . . . .                             | 37 |
| 7.2.9    | Camshaft Bearings . . . . .                                  | 38 |
| 7.2.10   | Camshaft . . . . .                                           | 38 |
| 7.2.10.1 | Camshaft Thrust Washer . . . . .                             | 38 |
| 7.2.11   | Camshaft Sprocket and Chain. . . . .                         | 38 |
| 7.2.12   | Camshaft Gear Bolt . . . . .                                 | 38 |
| 7.2.13   | Timing Gear Oil Deflector and Washer . . . . .               | 38 |
| 7.2.14   | Harmonic Balancer and Oil Slinger . . . . .                  | 38 |
| 7.2.15   | Engine Front Cover and Seal . . . . .                        | 39 |
| 7.2.16   | Timing Mark Indicator . . . . .                              | 39 |
| 7.2.17   | Oil Pump . . . . .                                           | 39 |
| 7.2.17.1 | Oil Pump Screen . . . . .                                    | 39 |
| 7.2.17.2 | Oil Pump Relief Valve . . . . .                              | 39 |
| 7.2.17.3 | Oil Pump Relief Valve Spring . . . . .                       | 39 |
| 7.2.18   | Dipstick Tube . . . . .                                      | 39 |
| 7.2.19   | Oil Pan . . . . .                                            | 39 |
| 7.2.20   | Cylinder Head Preparation . . . . .                          | 39 |
| 7.2.20.1 | Cylinder Head Freeze Plugs . . . . .                         | 40 |
| 7.2.20.2 | Deburring of Cylinder Head . . . . .                         | 40 |
| 7.2.20.3 | Machining of Valve Guides . . . . .                          | 40 |
| 7.2.20.4 | Valve Lapping . . . . .                                      | 40 |
| 7.2.20.5 | Valve Stem Seals . . . . .                                   | 40 |
| 7.2.20.6 | Cylinder Head Cleaning . . . . .                             | 40 |
| 7.2.20.7 | Valve Springs. . . . .                                       | 41 |
| 7.2.20.8 | Valve Travel Calibration . . . . .                           | 41 |
| 7.2.21   | Stud-Type Head Bolts<br>and Rocker Cover Deflectors. . . . . | 41 |
| 7.2.22   | Hydraulic Valve Lifters . . . . .                            | 41 |
| 7.2.23   | Push Rods . . . . .                                          | 41 |
| 7.2.24   | Intake Manifold. . . . .                                     | 41 |
| 7.2.24.1 | Modifications. . . . .                                       | 41 |
| 7.2.24.2 | Choke Stove . . . . .                                        | 41 |
| 7.2.24.3 | Deburring of Intake Manifold . . . . .                       | 42 |
| 7.2.24.4 | Gaskets . . . . .                                            | 42 |
| 7.2.25   | Rocker Cover Spacers and Gaskets . . . . .                   | 42 |

|           |                                                      |           |
|-----------|------------------------------------------------------|-----------|
| 7.2.26    | Water Inlet Adapter . . . . .                        | 42        |
| 7.2.27    | Breather Tube . . . . .                              | 42        |
| 7.2.28    | Thermostat Housing . . . . .                         | 42        |
| 7.2.29    | Fuel Pump and Eccentric. . . . .                     | 42        |
| 7.2.30    | Oil Filter Housing. . . . .                          | 42        |
| 7.2.31    | Oil Sample Line. . . . .                             | 42        |
| 7.2.32    | Ignition System . . . . .                            | 43        |
| 7.2.32.1  | High Energy Ignition (H.E.I.) Wire . . . . .         | 43        |
| 7.2.32.2  | Distributor Advance. . . . .                         | 43        |
| 7.2.32.3  | Vacuum Advance Unit . . . . .                        | 43        |
| 7.2.32.4  | Spark Plugs . . . . .                                | 43        |
| 7.2.33    | Carburetor . . . . .                                 | 43        |
| 7.2.34    | Accessory Drive Units . . . . .                      | 44        |
| 7.2.35    | Special Parts . . . . .                              | 44        |
| 7.2.36    | Exhaust Manifolds. . . . .                           | 44        |
| 7.2.37    | Engine Flywheel and Guards . . . . .                 | 44        |
| 7.2.38    | Pressure Checking of Engine Coolant System . . . . . | 44        |
| 7.2.39    | Lifting of Assembled Engines . . . . .               | 45        |
| 7.2.40    | Engine Mounts . . . . .                              | 45        |
| 7.2.41    | Drive Shaft . . . . .                                | 45        |
| <b>8.</b> | <b>TEST PROCEDURE . . . . .</b>                      | <b>47</b> |
| 8.1       | External Cooling System Cleaning . . . . .           | 47        |
| 8.2       | Engine Coolant Jacket Cleaning (Flushing) . . . . .  | 47        |
| 8.2.1     | Plumbing Connections . . . . .                       | 47        |
| 8.2.2     | Procedure . . . . .                                  | 47        |
| 8.3       | Coolant Charging . . . . .                           | 49        |
| 8.4       | Test Oil Charging . . . . .                          | 49        |
| 8.5       | Installation of Rocker Covers. . . . .               | 50        |
| 8.6       | Engine Startup and Shutdown Procedures . . . . .     | 50        |
| 8.6.1     | Startup . . . . .                                    | 50        |
| 8.6.2     | Shutdown . . . . .                                   | 50        |
| 8.7       | Timing Run . . . . .                                 | 50        |
| 8.8       | Oil Sampling . . . . .                               | 51        |
| 8.8.1     | Checks for Glycol Contamination . . . . .            | 51        |
| 8.9       | Oil Leveling . . . . .                               | 52        |

|           |                                                                      |           |
|-----------|----------------------------------------------------------------------|-----------|
| 8.10      | Operations . . . . .                                                 | 52        |
| 8.10.1    | Test Time . . . . .                                                  | 52        |
| 8.10.2    | Non-Scheduled Shutdowns . . . . .                                    | 52        |
| 8.10.3    | Dipstick and Guide Tube . . . . .                                    | 52        |
| 8.10.4    | Oil Fill Tube . . . . .                                              | 53        |
| 8.10.5    | Blowby Measurement . . . . .                                         | 53        |
| 8.10.6    | Coolant Additions . . . . .                                          | 53        |
| 8.10.7    | Carburetor Adjustments for AFR Control . . . . .                     | 53        |
| 8.10.8    | Carburetor Air Inlet Adapter . . . . .                               | 56        |
| 8.10.9    | Data Recording . . . . .                                             | 56        |
| 8.10.10   | Break-in (4 Hours). . . . .                                          | 58        |
| 8.10.11   | Test (64 Hours) . . . . .                                            | 61        |
| <b>9.</b> | <b>FINAL INSPECTION AND REPORTING . . . . .</b>                      | <b>63</b> |
| 9.1       | Engine Teardown and Elapsed Time . . . . .                           | 63        |
| 9.1.1     | Preparation of Parts for Deposit Ratings<br>and Inspection . . . . . | 63        |
| 9.1.1.1   | Parts Rated for Sludge<br>Deposits and/or Plugging . . . . .         | 63        |
| 9.1.1.2   | Pistons Rated for Varnish and<br>Ring Land Deposits . . . . .        | 63        |
| 9.2       | Method . . . . .                                                     | 63        |
| 9.2.1     | Sludge . . . . .                                                     | 63        |
| 9.2.2     | Varnish . . . . .                                                    | 63        |
| 9.2.3     | Ring Land Deposits . . . . .                                         | 63        |
| 9.2.4     | Scuffing and Wear (Visual Inspection) . . . . .                      | 64        |
| 9.2.5     | Camshaft and Lifter Wear . . . . .                                   | 64        |
| 9.2.6     | Rod Bearing Weight Loss . . . . .                                    | 64        |
| 9.2.7     | Plugging . . . . .                                                   | 64        |
| 9.2.7.1   | Oil Pump Screen . . . . .                                            | 64        |
| 9.2.7.2   | Oil Rings . . . . .                                                  | 67        |
| 9.2.8     | Sticking . . . . .                                                   | 67        |
| 9.2.8.1   | Rings . . . . .                                                      | 67        |
| 9.2.8.2   | Lifter Plungers . . . . .                                            | 67        |
| 9.2.8.3   | Oil Pump Relief Valve . . . . .                                      | 67        |
| 9.2.9     | Viscosity Measurement . . . . .                                      | 67        |
| 9.3       | Photographs of Test Parts . . . . .                                  | 67        |

|       |                                                      |           |
|-------|------------------------------------------------------|-----------|
| 9.4   | Reporting of Results . . . . .                       | 72        |
| 9.4.1 | Report Forms . . . . .                               | 72        |
| 9.4.2 | Calculation of Deposit Ratings . . . . .             | 72        |
| 9.4.3 | Oil Consumption Computation . . . . .                | 73        |
| 9.4.4 | Operational Test Parameters and Deviations . . . . . | 73        |
| 9.5   | Review of Representative Test Parts . . . . .        | 73        |
| 10.   | <b>GENERAL INFORMATION . . . . .</b>                 | <b>75</b> |
| 10.1  | Safety . . . . .                                     | 75        |
| 10.2  | Glossary of Definitions . . . . .                    | 77        |
| 10.3  | Glossary of Symbols and Terms . . . . .              | 78        |
| 10.4  | Document Precision Information . . . . .             | 79        |

## LIST OF FIGURES

| <u>No.</u> | <u>Description</u>                                                                | <u>Page No.</u> |
|------------|-----------------------------------------------------------------------------------|-----------------|
| 1.         | Correlation of Sequence IIID with Sequence IIIC . . . . .                         | 9               |
| 2.         | Sequence IIID Reference Oil Precision Data . . . . .                              | 10              |
| 3.         | Sequence IIID Commercial Oil Precision Data . . . . .                             | 11              |
| 4.         | Sequence IIID Operational Check List<br>and Oil Level Instruction Sheet . . . . . | 54              |
| 5.         | Sequence IIID Oil Sample, Level and<br>Consumption Records . . . . .              | 55              |
| 6.         | Sequence IIID Air to Fuel Ratio Chart . . . . .                                   | 70              |
| 7.         | Sequence IIID Daily Log . . . . .                                                 | 59              |
| 8.         | Sequence IIID Supplemental Daily Log . . . . .                                    | 60              |
| 9.         | Sequence IIID Sludge and Varnish Ratings Worksheet . . . . .                      | 65              |
| 10.        | Sequence IIID Piston Ring Oil Land Ratings Worksheet . . . . .                    | 10              |
| 11.        | Sequence IIID Test Results . . . . .                                              | 68              |
| 12.        | Sequence IIID Reference Test Results . . . . .                                    | 69              |
| 13.        | Sequence IIID Operational Summary . . . . .                                       | 70              |
| 14.        | Sequence IIID Viscosity Increase . . . . .                                        | 71              |

## APPENDICES

## Appendix A PROCUREMENT OF TEST MATERIALS

| <u>Section</u> | <u>Item</u>                                                            | <u>Page No.</u> |
|----------------|------------------------------------------------------------------------|-----------------|
| A.1            | General Communications Concerning Sequence IIID                        |                 |
|                | Reference Tests . . . . .                                              | 81              |
| A.2            | General Communications Concerning Sequence IIID                        |                 |
|                | Questions and Candidate Tests . . . . .                                | 81              |
| A.3            | Reference Oils . . . . .                                               | 81              |
| A.4            | Test Engines . . . . .                                                 | 81              |
| A.5            | Special Test Parts. . . . .                                            | 82              |
| A.6            | External Oil Pump . . . . .                                            | 82              |
| A.7            | External Oil System Heat Exchanger. . . . .                            | 82              |
| A.8            | External Oil System and Other Quick<br>Disconnect Fittings . . . . .   | 82              |
| A.9            | Fuel Pressure Regulator . . . . .                                      | 82              |
| A.10           | Fuel Shut-off Valve . . . . .                                          | 82              |
| A.11           | Humidity Measuring Equipment . . . . .                                 | 83              |
| A.12           | Thermocouples and Packing Glands . . . . .                             | 83              |
| A.13           | Exhaust Pipes . . . . .                                                | 83              |
| A.14           | Crankcase Pressure Gauge (Magnehelic) . . . . .                        | 83              |
| A.15           | Test Fuel . . . . .                                                    | 83              |
| A.16           | Glycol . . . . .                                                       | 83              |
| A.17           | Sodium Metaborate . . . . .                                            | 83              |
| A.18           | NACAP . . . . .                                                        | 84              |
| A.19           | Calcium Nitrate . . . . .                                              | 84              |
| A.20           | Sodium Nitrite . . . . .                                               | 84              |
| A.21           | Pluronic L-61 . . . . .                                                | 84              |
| A.22           | Decyl Alcohol . . . . .                                                | 84              |
| A.23           | Solvent S-26 . . . . .                                                 | 84              |
| A.24           | Oakite 77, Oakite II, Oakite Rust Stripper,<br>Oakite Drycid . . . . . | 84              |
| A.25           | Sovasol #5 . . . . .                                                   | 85              |
| A.26           | Perfect Seal No. 4 Sealing Compound . . . . .                          | 85              |
| A.27           | Permatex, No. 2 Non-Hardening and<br>Permatex 6BR . . . . .            | 85              |
| A.28           | 3M Super Weatherstrip Adhesive . . . . .                               | 85              |

|      |                                                   |    |
|------|---------------------------------------------------|----|
| A.29 | Anti-Seizure Compound . . . . .                   | 85 |
| A.30 | 3M Cloth . . . . .                                | 85 |
| A.31 | Breather Tube Gaskets. . . . .                    | 85 |
| A.32 | SAE 10W Mineral Oil (EF411) . . . . .             | 86 |
| A.33 | Desiccator for Paint Roller. . . . .              | 86 |
| A.34 | Intake and Exhaust Manifold Gaskets . . . . .     | 86 |
| A.35 | Piston Rings . . . . .                            | 86 |
| A.36 | Pistons . . . . .                                 | 86 |
| A.37 | Valve Lifters . . . . .                           | 87 |
| A.38 | Valve Stem Seals . . . . .                        | 87 |
| A.39 | Rocker Cover Gaskets . . . . .                    | 87 |
| A.40 | Valve Springs. . . . .                            | 87 |
| A.41 | Cylinder Hone . . . . .                           | 87 |
| A.42 | Ring Gap Feeler Gauge . . . . .                   | 87 |
| A.43 | Ring Grinder . . . . .                            | 88 |
| A.44 | Cam Bearing Installation Tool . . . . .           | 88 |
| A.45 | Valve Guide Cutter for Valve Stem Seals . . . . . | 88 |
| A.46 | Spark Plug Wire Removal Tool . . . . .            | 88 |
| A.47 | Driveshaft . . . . .                              | 88 |
| A.48 | Teri-Towels . . . . .                             | 89 |
| A.49 | CRC Rating Manuals No. 9 and No. 12 . . . . .     | 89 |

## **Appendix B PRINT LISTINGS**

| <u>Section</u> | <u>Item</u>            | <u>Page No.</u> |
|----------------|------------------------|-----------------|
| B.1            | Numerical . . . . .    | 91              |
| B.2            | Alphabetical . . . . . | 96              |

