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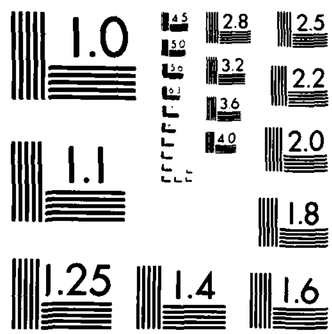

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CRC Report No. 542

(6)

1984 CRC OCTANE NUMBER REQUIREMENT RATING WORKSHOP

June 1985

COORDINATING RESEARCH COUNCIL, INC.
219 PERIMETER CENTER PARKWAY, ATLANTA, GEORGIA 30346

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June 28, 1985

CRC Project No. CM-124-84

Defense Document Center
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Alexandria, Virginia 22314

Gentlemen:

In accordance with the requirements stated in Contract Number DAAK-70-81-C-0128, enclosed are twelve copies of the following report which has been approved by the appropriate CRC Committee for transmittal to the Military and release for publication and general distribution by the Sustaining Members:

1984 CRC OCTANE NUMBER REQUIREMENT RATING WORKSHOP
(CRC Report No. 542)

Sincerely,

Beth Evans
Editor

BE:sb

Enclosures

COORDINATING RESEARCH COUNCIL
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1984 CRC OCTANE NUMBER REQUIREMENT RATING WORKSHOP

(CRC PROJECT No. CM-124-84)

Prepared by the

CRC Octane Technology and Test Procedures Group

DAAK 70-8-C-1128

June 1985

Light-Duty Vehicle Fuel, Lubricant, and Equipment Research Committee

of the

Coordinating Research Council, Inc.

ABSTRACT

An octane number requirement rating workshop was sponsored by the Coordinating Research Council May 7-11, 1984, in Phoenix, Arizona. The objective of the workshop was to improve the application of the CRC E-15 Technique for Determination of Octane Number Requirements of Light-Duty Vehicles to provide consistent results with vehicles equipped with knock sensors, turbochargers, and various transmission configurations such as torque converter lockups, four-speed overdrives, and five-speed manuals. Training was accomplished through seminars and demonstrations, and was verified with actual track testing using the E-15 rating technique and appropriate equipment.

TABLE OF CONTENTS

TEXT

		Page
	ABSTRACT	i
I.	INTRODUCTION	1
II.	TEST VEHICLES	1
III.	TEST FUELS	2
IV.	TEST PROGRAM	2
V.	ANALYSIS OF DATA	3
VI.	RECOMMENDATIONS FOR IMPROVING E-15 TECHNIQUE	4
VII.	RECOMMENDATIONS FOR FUTURE RATING WORKSHOPS	5

TABLES

Table I - Supplier's Fuel Inspections - 1983 FBRU Fuels............. 7

Table II - Octane Numbers and Compositions for 1983 FBRU Fuels....... 8

APPENDICES

Appendix A - Attendees of the 1984 CRC Octane Number Requirement Rating Workshop.................................. A-1

Appendix B - Program for the 1984 CRC Octane Number Requirement Rating Workshop.................................. B-1

Appendix C - Revised Technique for Determination of Octane Number Requirements (CRC E-15-84 Technique)............... C-1

Appendix D - Recommended Modifications to CRC Octane Number Requirement Rating Data Form DFMF-11-1184.......... D-1

I. INTRODUCTION

An octane number requirement rating workshop was sponsored by the Coordinating Research Council (CRC) May 7-11, 1984, in Phoenix, Arizona. The objective of the workshop was to improve the application of the CRC E-15 Technique for Determination of Octane Number Requirements of Light-Duty Vehicles to provide consistent results with vehicles equipped with knock sensors, turbochargers, and various transmission configurations such as torque converter lockups, four-speed overdrives, and five-speed manuals. The workshop was conducted in response to interest expressed. Although initial plans called for approximately twenty-five attendees, fifty technicians, raters, and engineers actually attended. Attendees of the workshop are listed in Appendix A. Training was accomplished through seminars and demonstrations, and was verified with actual track testing using the E-15 rating technique and appropriate equipment. A copy of the program is included as Appendix B.

II. TEST VEHICLES

Eleven 1984 model vehicles were available for track testing as follows:

- Buick, 3.0-liter, 2-barrel carburetor, electronic spark control, automatic transmission
- Buick, 3.8-liter, 2-barrel carburetor, electronic spark control, automatic transmission
- Buick, 3.8-liter, 2-barrel carburetor, electronic spark control, automatic transmission
- Buick, 3.8-liter, sequential-fuel-injected, electronic spark control, turbocharged, automatic transmission
- Chevrolet (truck), 5.0-liter, 4-barrel carburetor, electronic spark control, automatic transmission
- Chrysler, 2.2-liter, 2-barrel carburetor, manual transmission
- Chrysler, 2.2-liter, fuel-injected, electronic spark control, turbocharged, automatic transmission
- Ford, 2.3-liter, single-barrel carburetor, automatic transmission
- Ford, 3.8-liter, fuel-injected, electronic spark control, automatic transmission
- Nissan Sentra, 1.6-liter, 2-barrel carburetor, manual transmission
- Pontiac, 2.5-liter, throttle-body-injected, automatic transmission

Seven of the eleven vehicles were equipped with electronic spark control devices (which include the knock-sensor devices); two of the vehicles were turbocharged; and four of the vehicles were fuel-injected. There were only two vehicles with manual transmissions; the remaining nine vehicles were all equipped with automatic transmissions.

III. TEST FUELS

The test fuels used during the workshop were the 1983 CRC Full-Boiling Range Unleaded (FBRU) fuels. The fuels were prepared from three base blends (RMFD-344-83, RMFD-345-83, and RMFD-346-83) in two octane number increments from 78 to 84 Research octane number (RON), and in one octane number increments from 84 to 102 RON.

The base blends were prepared from normal refinery components. Inspection data furnished by the supplier are given in Table I. The composition and average laboratory octane data for the 1983 FBRU reference fuel series are presented in Table II.

IV. TEST PROGRAM

The workshop was divided into two three-day sessions, with a one-day overlap. It was conducted May 7-11, 1984, at the Firebird International Raceway located on the outskirts of Phoenix, Arizona. The timing of the workshop was planned such that the results of it could be used for the 1984 CRC Octane Number Requirement Survey.

Each session began with classroom-type discussion of problems encountered with the E-15 Technique over the last several years. Changes to the Technique recommended during the discussion were then verified by actual track testing. Major problems which the raters had experienced with the E-15 were:

- Definition of borderline (along with above and below borderline) knock for both conventional and knock sensor-equipped vehicles;
- Maximum-throttle acclerations for turbocharged cars (vacuum/pressure versus speed profiles); and
- Converter lockup clutches.

During the discussion periods, representatives from several of the automobile manufacturers presented information intended to clarify the knock-sensor devices currently in use on their vehicles. These representatives were also available to answer individual questions about their respective knock-sensor systems.

Since the purpose of the workshop was to be an educational experience rather than a source of octane requirement data, emphasis was placed upon exchange of information as opposed to data collection and analysis. The intent of the workshop was not to "rate the raters," but to reduce the laboratory-to-laboratory variations in the application of the E-15 Technique. Classroom discussions were held at various intervals during the track testing to elaborate on what had been learned during the actual track testing experience. Raters from different companies were assigned to work together in an effort to improve and promote communication among raters on the various ways in which different laboratories employ the E-15 Technique. The consensus of the workshop attendees was that this was an extremely successful way to learn better and more consistent methods of utilizing the E-15.

V. ANALYSIS OF DATA

This report contains no analysis of the data submitted during the workshop, because the data do not offer any information about the operations of the workshop. The workshop was designed to improve the application of the E-15 Technique, and its success was the clarification of the technique among the participants in the workshop. In addition, the workshop participants recommended clarifications in the actual documents defining the E-15 Technique.

The individual data sheets were reviewed on-site shortly after the completion of the rating of a vehicle. This review was primarily concerned with the proper completion of the rating form; however, it was noted if the rating appeared to be inconsistent with other ratings. Based upon this information, the individual rater was approached, and any necessary corrective actions were discussed with him as soon as possible.

The complete set of data for all of the vehicles has been reviewed and found to be of little value for evaluating the raters. This is not surprising, since the program was not designed for this purpose and was not expected to provide this type of information. The major difficulty in making any evaluation of individual raters was due to operational conditions which could be expected to cause wide variations in the individual vehicle ratings. The major influence was the ambient temperature which varied from 70°F to 105°F, and which should be expected to have a large direct effect on the octane requirement. Also, due to the high temperatures and the auxiliary fueling system, a number of the veicles suffered from vapor lock conditions during rating, which caused lean carburetion, and which was not always detected. The vehicles were also being continuously rated, which normally causes a decrease in the requirement due to severe service. These effects could not be separated from the rater effects; thus, evaluation was not possible.

VI. RECOMMENDATIONS FOR IMPROVING E-15 TECHNIQUE

Along with various minor modifications intended to clarify the procedure, several recommendations were made to simplify and improve the E-15. These recommendations were transmitted to the Steering Panel of the CRC Octane Number Requirement Survey Group for their action. The Steering Panel incorporated the recommendations into the E-15-84 Technique which was subsequently distributed to the Group members for their use in the 1984 CRC Octane Number Requirement Survey. The revised E-15-84 Technique is included as Appendix C of this report, and the recommended changes are indicated by italics. The changes do not substantially alter the substance nor the scope of the E-15 Technique, but they do serve to clarify instructions to raters and update the rating technique to include knock sensor-equipped vehicles. Significant modifications to the Technique were concerned with the DEFINITION OF TERMS. Other changes were made either for safety considerations or were editorial in nature. The major modifications to the Technique are as follows:

Spark Knock is defined essentially as it has been in the past. Surface ignition knock is eliminated, because it does not occur often enough in modern engines to be a factor. The previous definition of knock had included surface ignition knock as knock preceded by a surface ignition.

Borderline Knock is now defined as a spark knock of lowest audible intensity of at least three pings over a speed range of at least 50 rpm, and repeatable in subsequent accelerations. Borderline knock was previously defined as a spark knock of lowest audible intensity, recurrent surface ignition knock of borderline intensity, or infrequent (three or less) surface ignition knocks regardless of intensity.

Minimum Requirement (for knock-sensor vehicles) is defined as the lowest octane reference fuel giving borderline knock (as described above). The next lower fuel will give above-borderline knock. Two above-borderline (A) rating accelerations are needed to terminate investigation. This clarification expands the previous definition which referred to minimum requirement only as the lowest octane fuel that gives borderline knock.

Establishment of Representative Knock Intensity for a given fuel will now be accomplished with a maximum of three rating accelerations. Coastdown time between the end of one acceleration and the beginning of the next should be approximately twenty seconds. The previous version of the E-15 Technique only stated that establishment of representative knock intensity for a given fuel should be accomplished with the fewest number of accelerations possible. No direction was given regarding coastdown time between the end of one acceleration and the beginning of the next.

Recommended modifications to the CRC octane number requirement rating data form DFMF-11-1184 are shown in Appendix D. These recommended changes are primarily intended to clarify and simplify the rating form.

VII. RECOMMENDATIONS FOR FUTURE RATING WORKSHOPS

The consensus of the attendees was that, due to its value, an octane number requirement rating workshop should be conducted at least every two years. It was also suggested that additional track time be available, with a reduction in the amount of formal discussion time. Because of its success, there was a great deal of support for comprising rating teams at future workshops from raters from different companies. An additional recommendation was to include chassis dynamometer work in the next workshop, since so many laboratories rate on chassis dynamometers.

TABLES

D. TEST PROCEDURE

1. Engine Warm-Up

a. To stabilize engine temperatures, a minimum of ten miles of warm-up is required. The test vehicle should be operated at 55 mph (88 kph) in top gear with a minimum of full-throttle operation.

b. During the warm-up period, the general mechanical condition of the vehicle should be checked to insure satisfactory and safe operation during test work.

2. Fuel Changeover

Caution: Because of the installation of catalytic devices on these vehicles, permanent damage may result if the engine runs lean or stalls. Therefore, changeover from one fuel to another must be accomplished without running the carburetor or fuel injection system dry. Fuel handling procedures for vehicles equipped with fuel injection systems are explained in Attachment A.

To eliminate contamination of the new fuel with residual amounts of the previous fuel, flush system twice with new fuel.

After fuel changeover, make one maximum-throttle acceleration before beginning Vehicle Rating Procedure.

3. Details of Observations

a. Operating Conditions

All octane number requirements will be determined under level road acceleration conditions.

Tests will be conducted on moderately dry days, preferably at ambient temperatures between 60°F (15.5°C) and 90°F (32.2°C). Tests should not be conducted during periods of high humidity such as prevail when rain is threatening or during or immediately after a rain storm. Laboratories with control capabilities should target for 70°F (21°C) air temperature and 50 grains of water per pound (7.14 gm/kg) of dry air whenever possible.

Air-conditioned vehicles will be tested with air conditioner turned ON. (Normal setting, minimum temperature, low fan.) Air conditioner will be ON at all times.

C. VEHICLE PREPARATION

The following vehicle preparation steps should be completed before any octane tests are run. Detailed procedures for each adjustment can be found in the manufacturers' shop manuals.

1. Record vehicle identification number and emission control type, Federal, Altitude, or California. Fill in heading on data sheet DFMF-11-1184. For knock sensor-equipped vehicles, two DFMF-11-1184 data sheets should be filled out completely: one for maximum requirement, and one for minimum requirement. Ford emission calibration numbers are to be recorded.

2. Inspect all vacuum lines and air pump hoses for appropriate connections. Also, check to see if PCV valve, spark advance vacuum delay controls, EGR valve, knock sensors, and heated inlet air mechanism are functioning. Engine must be warmed up for these checks.

3. Record engine idle speed and observe anti-dieseling solenoid operation. Adjust to manufacturers' recommended specifications as specified on the under-hood decal.

4. Observe and record basic spark timing at recommended engine speed. Adjust to manufacturers' recommended setting as specified on the under-hood decal.

5. Crankcase oil, radiator coolant, automatic transmission fluid, and battery fluid levels shall be maintained as recommended by the manufacturer.

6. A calibrated tachometer graduated in 100 rpm (or smaller) increments and capable of indicating engine speed from 0-5000 rpm shall be installed on each vehicle.

7. One calibrated vacuum gage, graduated in one-half inch of mercury (or smaller) increments and capable of indicating vacuum from 0-24 inches of mercury (0-81 kPa) shall be connected to the intake manifold. *For vehicles with turbochargers, a compound vacuum/pressure gage should be used; the pressure side of the gage should be capable of indicating pressures up to 15 psi (103 kPa).*

8. An auxiliary fuel system shall be provided to supply test fuels to the engine. Caution shall be taken to avoid placing auxiliary fuel lines in locations which promote vapor lock. If vehicles with carbureted engines have tank return fuel lines, this return line should be blocked off. Disconnect fuel tank vent line at evaporation control system canister. Instructions for fuel handling with fuel injection systems are given in Attachment A.

9. For vehicles with owner questionnaire completed, a sample of the tank gasoline shall be withdrawn for determination of Research and Motor method octane number ratings. *If insufficient fuel is available, omit this step and obtain tank fuel observations as described in Item D.3.d.(2).*

b. No Knock

This means either no audible knock or less than borderline knock.

c. Above Borderline Knock

This means spark knock of greater than borderline intensity.

3. *Octane Number Requirements*

a. *Maximum Requirement*

This is equivalent to the octane number of the highest reference fuel giving borderline knock as previously defined (the next higher fuel gives no knock). If the knock intensity with the highest fuel giving knock is above borderline, the maximum requirement shall be equivalent to the mid-point between the octane number of the fuel giving knock and that of the next higher fuel which gives no knock.

b. *Minimum Requirement (for vehicles with knock sensors)*

This is equivalent to the octane number of the lowest reference fuel giving borderline knock (the next lower fuel will give above borderline knock).

4. Definition of Accelerations

Accelerations are made at maximum-throttle and part-throttle conditions which are defined below:

a. Maximum-Throttle

The throttle is depressed and held at either full-throttle or the widest throttle position that does not cause the transmission to downshift (detent) throughout the acceleration in each of the required test gears listed in D.3.d.(1)(a). The detent manifold vacuum/*pressure* obtainable on a given model is determined by the transmission characteristics. For manual transmissions, the throttle is depressed fully throughout the acceleration.

b. Part-Throttle

The throttle is depressed and regulated throughout the acceleration to maintain a desired, constant critical manifold vacuum as defined in D.3.d.(1)(d).

TECHNIQUE FOR DETERMINATION OF OCTANE NUMBER REQUIREMENTS OF LIGHT-DUTY VEHICLES

(CRC Designation E-15-84 - Including Attachment A)

A. GENERAL

The technique provides for the determination of maximum octane number requirements (*and minimum octane number requirements for vehicles equipped with knock sensors*), whether at maximum-throttle or part-throttle, of a vehicle in terms of borderline spark knock on two series of full-boiling range reference fuels as well as on primary reference fuels. If the maximum requirement is at maximum-throttle, then part-throttle requirements are investigated with only FBRU fuels of up to, and including, four octane numbers lower than the maximum requirement. It also provides octane requirements throughout the speed range on primary reference fuels.

Spark knock of tank fuel will also be determined.

B. DEFINITION OF TERMS

The following definitions of knock, approved by the CLR and CFR Committees on June 8, 1954, have been rephrased for clarification and adaptability to current technology by the Survey Steering Panel.

1. Spark Knock:

Spark knock is the noise associated with autoignition* of a portion of the fuel-air mixture ahead of the advancing flame front. It is recurrent and repeatable in terms of audibility and fuel octane quality.

2. Knock Intensity

a. Borderline Knock

This means spark knock of lowest audible intensity of at least three (3) pings, and over a range of engine speed of at least 50 rpm, all being repeatable during subsequent accelerations.

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* Autoignition: The spontaneous ignition and the resulting very rapid reaction of a portion or all of the fuel-air mixture. The flame speed is many, many times greater than that which follows normal spark ignition. There is no time reference for autoignition.

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TECHNIQUE FOR DETERMINATION OF OCTANE NUMBER REQUIREMENTS OF LIGHT-DUTY VEHICLES

(CRC Designation E-15-84)

September 1984

NOTE: *Recommended changes resulting from the 1984 CRC Octane Rating Workshop are indicated by italics.*

APPENDIX C

REVISED TECHNIQUE FOR DETERMINATION OF OCTANE NUMBER REQUIREMENTS (CRC E-15-84 TECHNIQUE)

- Locate Suitable Test Track Facilities
- Overall Coordination During Workshop
- Motel Accommodations and Logistics
- Group Sessions: Planning and Conduct
- Track Preparation and Operations
- Test Equipment
- Test Vehicles: Procurement, Instrumentation, Preparation
- Test Fuels: Procurement of Fuels and Cans, and Coordination of On-Site Handling
- Data Handling and Analysis

V. CARS

Approximately eight to ten 1983 and 1984 model cars with a minimum of 6,000 deposit miles will be rented and instrumented for track-testing. Some of the cars should have standard-ignition systems, but most should be equipped with knock sensor-controlled retard systems.

VI. FUELS

The fuel used will be the 1983 CRC Full Boiling Range Unleaded (FBRU) fuel. The fuel has been purchased for the program.

VII. WORKSHOP SCHEDULE

The workshop will run from Monday through Friday, and will be split into two three-day sessions with a one-day overlap.

Although a detailed schedule cannot be developed until the number of participants is known, it is likely that each crew will rate at least three cars during the course of the workshop. The basic plan consists of:

- Review of CRC E-15 Technique
- Open Discussion
- Track Orientation
- Track Testing with Observers
- Group Seminar to Discuss and Resolve Observed Variations in Techniques
- Repeat Test Runs Including Car-Type Changes
- Closing Discussions of Techniques and Program Evaluation

VIII. PARTICIPATION

The workshop has been planned on the basis of the following participation by each company: (1) an engineer responsible for E-15 driving activities; and (2) a rating crew, preferably experienced. The engineer and the rating crew should both attend at least one of the three-day sessions. If multiple crews are sent, one engineer would be sufficient, but should attend the same sessions as the rating crews.

The engineering personnel will be expected to participate in the discussions of the demonstrations, monitor test procedures in the cars and help with the E-15 Technique, and handle the logistics of the test track operation. A significant amount of planning, preparation, and coordination will be required to assure success of the workshop. Major activities needing attention are listed below:

PROGRAM FOR 1984 CRC OCTANE NUMBER REQUIREMENT RATING WORKSHOP

I. FOREWORD

It has been the goal of participants in CRC-sponsored fuel road rating and vehicle octane number requirement programs to reduce the laboratory-to-laboratory differences in the application of rating techniques. To this end, a CRC Octane Number Requirement Rating Workshop was held in 1979 to encourage the uniform application of the CRC E-15 Technique (Octane Number Requirement). It was generally felt that the workshop was quite beneficial and should be repeated every two or three years.

At the March 2, 1983, meeting of the CRC Road Test Group (now the CRC Octane Technology and Test Procedures Group), interest was shown in having another rating symposium with an emphasis on rating vehicles equipped with knock sensors. The preferred time for this was found to be in the spring of 1984, so that the results could be used for the 1984 CRC Octane Number Requirement Survey.

II. OBJECTIVE

The objective of this workshop is to improve the application of the E-15, particularly that portion relating to the knock sensor-equipped vehicles.

III. SCOPE AND TIMING

Training will be accomplished through seminars and demonstrations, and verified with actual track testing using rating technique and equipment. The workshop is currently targeted for a one-week period in the spring. To accommodate the expected number of participants, the workshop will run from Monday through Friday, and will be split into two three-day sessions, with a one-day overlap.

IV. FACILITIES

The plan calls for track-testing, so a suitable closed or limited access track will have to be found. The selected track needs to have adequate meeting facilities to accommodate the seminars and be close for demonstration and practice test runs. A southwestern location is highly desirable because of a need for stable good weather.

APPENDIX B

PROGRAM FOR THE

1984 CRC OCTANE NUMBER REQUIREMENT RATING WORKSHOP

PARTICIPANTS IN THE 1984 CRC OCTANE NUMBER REQUIREMENT RATING WORKSHOP

Name	Company Affiliation
Rod Aguilar	Ford Motor Company (Arizona Proving Grounds)
John B. Baker	Shell Development Company
Bruce Bark	Ford Motor Company (Arizona Proving Grounds)
Daniel P. Barnard	Standard Oil Company (Ohio)
Jack D. Benson	General Motors Research Laboratories
Keith A. Blasius	Ford Motor Company
Jeff L. Borzone	Mobil Research and Development Corporation
Roland A. Bouffard	Exxon Research and Engineering Company
Greg Brooks	Union Oil Company of California
Sam Casimere	Shell Development Company
David H. Coleman	General Motors Research Laboratories
Phil L. Crisher	Ford Motor Company
Richard Dickerson	Sun Tech, Inc.
Doug Dudzik	ARCO Petroleum Products Company
Frank Eakins	Ford Motor Company (Arizona Proving Grounds)
Beth Evans	Coordinating Research Council
John D. Fowlks	Exxon Research and Engineering Company
Vance Fraser	Southwest Research Institute
Donald C. Gibbs	Mobil Research and Development Corporation
Paul R. Haagen	Chevron Research Company
Warner L. Healy	Chevron Research Company
Brian Hedden	Imperial Oil Research
Ray Higuera	General Motors Desert Proving Grounds
John Krylowski	Exxon Research and Engineering Company
John Lawrie	Standard Oil Company (Ohio)
Vonn E. Leatherman	Shell Development Company
R. Vance McCabe, Jr.	General Motors Research Laboratories
Doug McCorkell	Union Oil Company of California
James D. Merritt	Amoco Oil Company
Michael J. Mlotkowski	Mobil Oil Corporation
John Pandosh	Sun Tech, Inc.
Gary Parker	Exxon Research and Engineering Company
Gary L. Pedinelli	Ford Motor Company
J. Don Pivonka	General Motors Desert Proving Grounds
Jerry Quintrell	Southwest Research Institute
John A. Richey	Phillips Petroleum Company
Rick K. Riley	Phillips Petroleum Company
Peter Sarvos	Shell Canada
George H. Schafer	Texaco Inc.
Charlie P. Sherwood	Ford Motor Company
John J. Sidor	Standard Oil Company (Ohio)
Laszlo I. Slenkai	Ford Motor Company
Clinton R. Smith	Imperial Oil Research
Richard L. Swartzlander	Gulf Research and Development Company
Ray Szwabowski	ARCO Petroleum Products Company
Richard J. Tither	Mobil Oil Corporation
Sam D. Vallas	Amoco Oil Company
Douglas A. Voss	Chevron Research Company
Andy Vukovic	Shell Canada
Dave G. Werthmann	Ford Motor Company

APPENDIX A

ATTENDEES OF THE

1984 CRC OCTANE NUMBER REQUIREMENT RATING WORKSHOP

TABLE II

OCTANE NUMBERS AND COMPOSITIONS FOR 1983 FBRU FUELS

RON	Blending Data Composition, Volume Percent RMFD 344-83	RMFD 345-83	RMFD 346-83	MON	SEN
78	96	4	--	74.2	3.8
80	82	18	--	75.8	4.2
82	67	33	--	77.4	4.6
84	52	48	--	78.9	5.1
85	44	56	--	79.6	5.4
86	36	64	--	80.3	5.7
87	29	71	--	80.9	6.1
88	21	79	--	81.6	6.4
89	13	87	--	82.2	6.8
90	5	95	--	82.8	7.2
91	--	97	3	83.5	7.5
92	--	90	10	84.1	7.9
93	--	83	17	84.7	8.3
94	--	76	24	85.4	8.6
95	--	69	31	86.0	9.0
96	--	61	39	86.7	9.3
97	--	53	47	87.3	9.7
98	--	44	56	88.0	10.0
99	--	35	65	88.0	10.2
100	--	27	73	89.5	10.5
101	--	19	81	90.3	10.7
102	--	9	91	91.2	10.8

TABLE I

SUPPLIERS' FUEL INSPECTIONS

1983 FBRU FUELS

	Low-Octane Base Blend RMFD 344-83	Intermediate-Octane Base Blend RMFD 345-83	High-Octane Base Blend RMFD 346-83
Laboratory Inspection			
Distillation, °F			
IBP	93	95	95
10% Evap.	123	123	125
30% Evap.	159	162	181
50% Evap.	195	210	235
70% Evap.	233	257	261
90% Evap.	297	317	294
End Point	390	414	385
Gravity, °API	66.3	59.1	51.1
RVP, psi	8.5	8.6	8.5
Lead, g/gal.	<0.003	<0.003	<0.003
Oxidation Stability, hr.	>24	>24	>24
Hydrocarbon Type, Vol. %			
Aromatics	20.0	37.0	57.0
Olefins	2.0	3.0	1.0
Saturates	78.0	60.0	42.0
Research Octane Number	77.4	90.6	102.8
Motor Octane Number	73.7	82.9	91.8
Sensitivity	3.7	7.7	11.0

b. <u>Order of Fuel Testing</u>

1) Tank
2) FBRSU
3) FBRU
4) Primary

c. <u>Determination of Knock Intensity</u>

Maximum octane requirements will be established by evaluating the occurrence of knock in terms of knock intensity: "N" for none, "B" for borderline, and "A" for above borderline. Establishment of representative knock intensity for a given fuel will be accomplished with a maximum of three (3) rating accelerations. *Coastdown time between the end of one acceleration and the beginning of the next should be approximately twenty (20) seconds.* As defined below, the first two duplicating accelerations are sufficient with "N" and "B" intensity.

Acceleration Number 1	2	3	Representative Rating
N	N	-	N
N	B	N	N
N	B	B	B
B	N	B	B
B	B	-	B
B	A	-	A
A	-	-	A

All subsequent accelerations will normally be discontinued when "A" knock intensity is experienced, and testing continued with a higher octane number fuel in that series. <u>An exception will be made if "A" knock is experienced on the highest octane fuel which knocks in the engine</u>. In this case, it may be necessary to run additional accelerations to determine the speed of maximum knock intensity. If "A" knock is experienced at initiation of acceleration, as limited by transmission characteristics, this speed will be considered the speed of maximum knock. Otherwise, the midpoint between knock-in and knock-out will be considered the speed of maximum knock. When establishing knock-in and knock-out, back off on the throttle between points to eliminate "A" knock.

Minimum octane number requirements (for vehicles equipped with knock sensors) will be established in a similar manner except that when "A" knock intensity is encountered, subsequent accelerations will be made with a given fuel until duplicate "A" ratings are obtained over a measurable range of engine speeds as indicated below:

Acceleration Number			Representative Rating
1	2	3	
B	A	B	B
B	A	A	A
A	A	-	A
A	B	B	B

d. Determination of Octane Requirements

Tests should be run to 60 mph (97 kph) unless required to terminate at 55 mph (88 kph) because of legal speed limits.

(1) Vehicle Operating Procedure

(a) Establishment of Automatic Transmission Characteristics (for Maximum-Throttle Accelerations)

Obtain the transmission downshift characteristics of engine rpm and manifold vacuum/*pressure* at 25, 35, 45, and 55 mph (40, 56, 72, and 88 kph) incremental speeds (as obtainable in each gear), by movement of the throttle through the detent, i.e., downshift, throttle position. Also determine the minimum attainable road speed. These characteristics are to be determined for each of the gears specified in the table below. For transmissions with converter clutches, determine the minimum road speed for clutch application. At this initial speed and at 10 mph (16 kph), increments up to about 60 mph (97 kph) determine minimum vacuums (*pressures*) for application. Record all road speed/engine rpm/vacuum *or pressure* measurements from above on data sheet.

Do not use brakes, turn signals or hazard flashers during accelerations as these may affect electronic engine controls.

The selection of required test gears, and test gear/converter clutch combinations (if applicable) for various types of transmissions are listed below. Transmissions not explicitly described should be tested in a manner as similar as possible to those listed. Automatic transmission vehicles should be tested with the gear selector in D or O.

TRANSMISSION GEAR SELECTION

AUTOMATICS

Place the selector in "D" or "O" and check for critical condition.

Type	Gears to be Tested
GM 4-speed	4th gear, converter clutch engaged 3rd gear, converter clutch disengaged 2nd gear, converter clutch disengaged
GM 3-speed	3rd gear, converter clutch engaged 3rd gear, converter clutch disengaged 2nd gear, converter clutch disengaged
Ford 4-speed overdrive	4th gear 3rd gear 2nd gear
Other 3-speed	3rd gear 2nd gear

MANUALS

5-speed	4th and 3rd gears
4-speed	4th and 3rd gears
3-speed	3rd and 2nd gears

(b) Maximum-Throttle *Accelerations* - Automatic Transmissions

For maximum-throttle accelerations in each of the gears and gear/converter clutch combinations specified above, accelerate at the detent/application condition according to the speed versus vacuum/*pressure* profiles determined in (a) from the minimum obtainable speed up to 60 mph (97 kph). If the transmission downshifts, abort and start the acceleration again. Start with the highest gear or gear/clutch combination and proceed in descending order.

(c) Maximum-Throttle *Accelerations* - Manual Transmissions

Select the highest gear as specified in the table above. Start at the lowest speed from which the vehicle will accelerate smoothly or 30 mph (48 kph), whichever is higher, and depress the throttle full throughout the acceleration up to 60 mph (97 kph).

Select the next lower gear specified in the table above and accelerate at full throttle from the minimum speed from which the vehicle will accelerate smoothly up to 60 mph (97 kph).

(d) Part-Throttle *Accelerations* (Both Automatic and Manual Transmissions)

Select the highest gear up to the minimum vehicle speed at which the converter clutch will engage, and the highest gear/converter clutch combination above this minimum speed, to obtain the critical part-throttle vacuum *or pressure*. To obtain the critical part-throttle vacuum/*pressure*, first operate at road load (constant speed), at 25, 35, 45, and 55 mph (40, 56, 72, and 88 kph) incremental speeds (if obtainable in the specified gear). At each speed, move the throttle (in 3 to 5 seconds) from the road-load vacuum to:

1. one inch Hg (3.4 kPa) above full-throttle vacuum for manual transmissions;

2. *one inch Hg (3.4 kPa) above detent vacuum for automatic transmissions without converter clutches;*

3. one inch Hg (3.4 kPa) above the minimum vacuum at which the converter clutch disengages for so-equipped automatic transmissions.

The vehicle brakes may be applied lightly, if necessary, to maintain vehicle speed during throttle fanning, except for vehicles with converter clutch transmissions or EGR cut-outs.

If knocking occurs within any of the vacuum/*pressure* ranges, establish the manifold vacuum/*pressure* which gives maximum knock intensity on each fuel series. This is the critical vacuum/*pressure* to be used for all subsequent constant-vacuum/*pressure* part-throttle accelerations from the minimum obtainable speed in the test gear to 60 mph (97 kph), or until the vehicle ceases to accelerate. This critical vacuum/*pressure* should be determined for each reference fuel series.

(2) Tank Fuel Observations on Vehicles with Owner's Questionnaire

Investigate for maximum-throttle and part-throttle knock as detailed in Item 3d(1). Define maximum knock intensity as per Item 3c. Record maximum knock intensity, speed of maximum knock intensity, and manifold vacuum/pressure at each operating condition.

(3) Vehicle Rating Procedure (for Rater)

Knock rating should be performed while in a normal seated position (head above instrument panel) with floor mats in place.

Step 1 - After Tank Fuel Observations, use a fuel estimated to give borderline knock in a given fuel series and investigate for incidence of knock under conditions as described in D.3.d.(1)(b) above, and D.3.d.(1)(c) above, whichever is applicable.

Step 2 - If no knock occurs, go to a lower octane number blend in that series and repeat Step 1.

Step 3 - If knock occurs at one or more of the operating conditions in Step 1, continue investigation at the critical condition(s) with higher octane blends until highest octane fuel giving knock is determined within one octane number or one blend (*the next higher fuel gives no knock*). Record maximum knock intensity on all fuels. Record speed of maximum knock intensity and manifold vacuum (*pressure*) on highest octane fuel that knocks.

Step 4 - Using the lowest octane blend that did not knock in Step 3, investigate for incidence of part-throttle knock as described in D.3.d.(1)(d). If knock occurs, continue investigation at critical vacuum/*pressure* until requirement is defined. Record maximum knock intensity and critical manifold vacuum/*pressure* on all fuels, and speed of maximum knock intensity on highest octane fuel that knocks.

Step 5 - With FBRU fuel only, if no knock occurs in Step 4, go to a lower octane number blend and repeat Step 4. Discontinue part-throttle investigation if knock is not observed with a fuel four octane numbers lower than determined in Step 3.

Step 6 - For knock sensor-equipped vehicles after determination of maximum requirement, continue with lower octane blends until the lowest octane fuel giving borderline knock is determined.

The rating procedure is given in arrow diagram form on page C-13 for maximum requirement, and on page C-14 for minimum requirement, for knock sensor-equipped cars.

(4) Octane Number Requirement Over Speed Range

Octane requirements over the speed range will be obtained on primary reference fuels only, using throttle position for maximum requirements. These will be established by recording the knock-in and knock-out points during maximum requirement accelerations with each incremental fuel investigated. It may be necessary to test one or two additional lower octane fuels to describe the knocking characteristics over the speed range. Accelerate at maximum requirement throttle position from minimum obtainable speed as determined in 3d(1)(a), up to 3750 rpm, if necessary, in order to define requirements. These should be run to 60 mph (97 kph) unless required to terminate at 55 mph (88 kph) because of legal speed limits. If 3750 rpm cannot be attained in top gear, accelerations shall be discontinued and resumed in the next highest gear from 500 rpm below the engine speed at which top gear accelerations were determined.

When "A" knock is experienced, continue the acceleration, but back off on the throttle to maintain "B" knock until just prior to the knock-out point.

E. INTERPRETATION OF DATA

The data will be recorded on data sheet DFMF-11-1184. For knock sensor-equipped vehicles, two DFMF-11-1184 data forms should be filled out completely: one for maximum requirement, and one for minimum requirement. Octane requirements for all reference fuels shall be determined as follows:

1. If the knock intensity of the highest *reference* fuel giving knock is borderline, the requirement shall be reported as the octane number of that fuel.

2. If the knock intensity of the highest fuel giving knock is above borderline, the requirement shall be reported as the *mid-point between the octane number of the* fuel giving knock and that of the next higher fuel.

3. If the octane requirement in high gear is equal to the requirement in a lower gear, report the highest gear data.

4. For part-throttle requirements, report the data from the critical manifold vacuum/*pressure* observations.

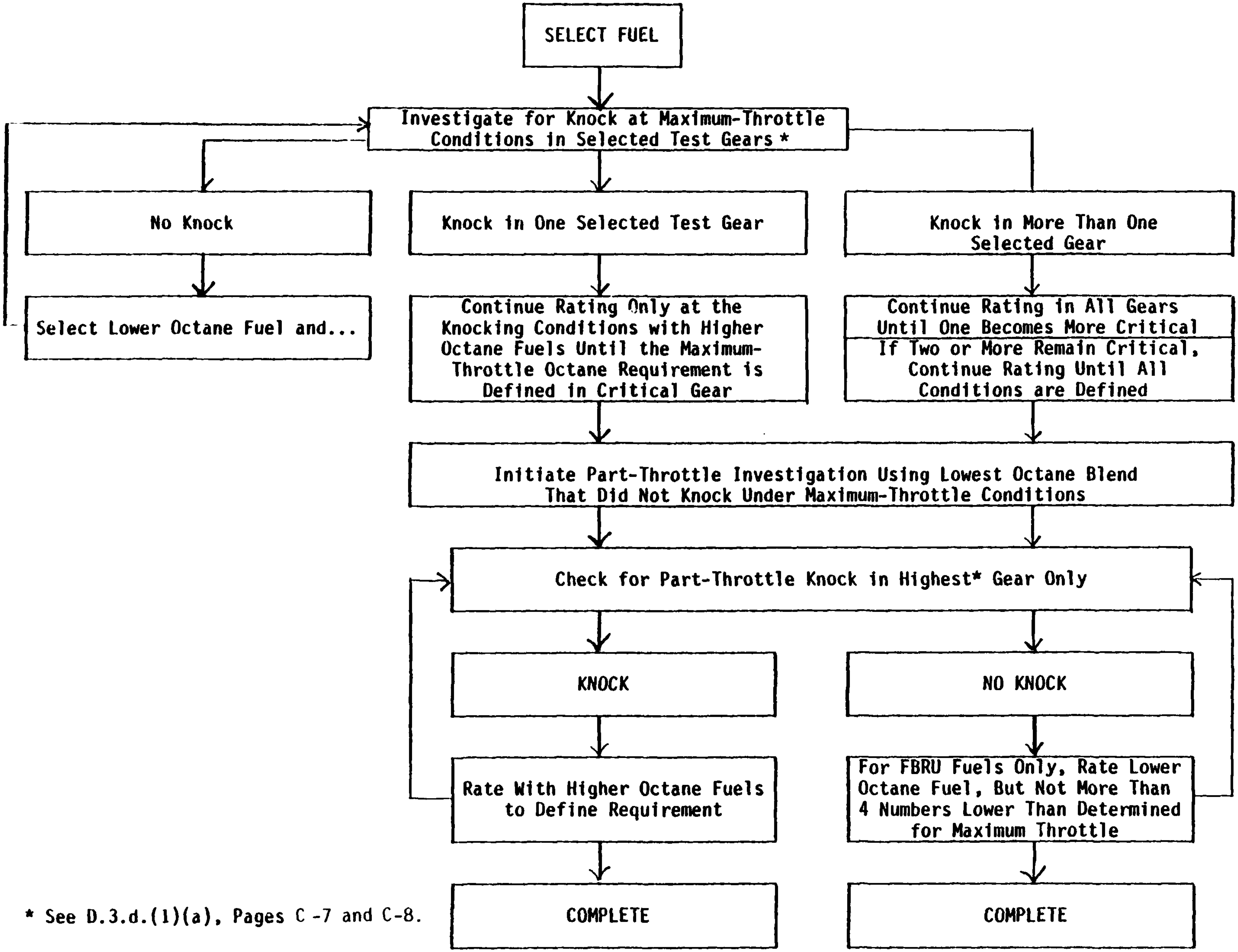
5. For knock sensor-equipped vehicles, report the highest and lowest fuel giving borderline knock.

Speed range data shall be reported on data sheet DFMF-11-1184 as the engine speed of knock-in and knock-out for the octane number of the primary reference fuel tested.

Record data on all fuels tested, even though knock was not encountered. When transferring data to the summary block, record the higher requirement, either part-throttle or maximum-throttle condition, for all fuels. If the higher requirement is part-throttle, record the part-throttle FBRU requirement in both the maximum and part-throttle columns. *If part-throttle and maximum-throttle requirements are equal on FBRU fuels, record the maximum-throttle data in the maximum-requirement columns and the part-throttle data in the part-throttle columns.* Use proper letter designation (see footnotes on data sheet) to designate requirements outside of the reference fuel limits or FBRU part-throttle requirement more than four numbers below maximum.

Requirements for the various engine speeds will be determined by fitting a smooth curve through the knock-in and knock-out points on work form DFMF-12-1184. Primary reference fuel requirements at various engine speeds should be reported to the nearest one-half octane number and recorded on the speed range summary block.

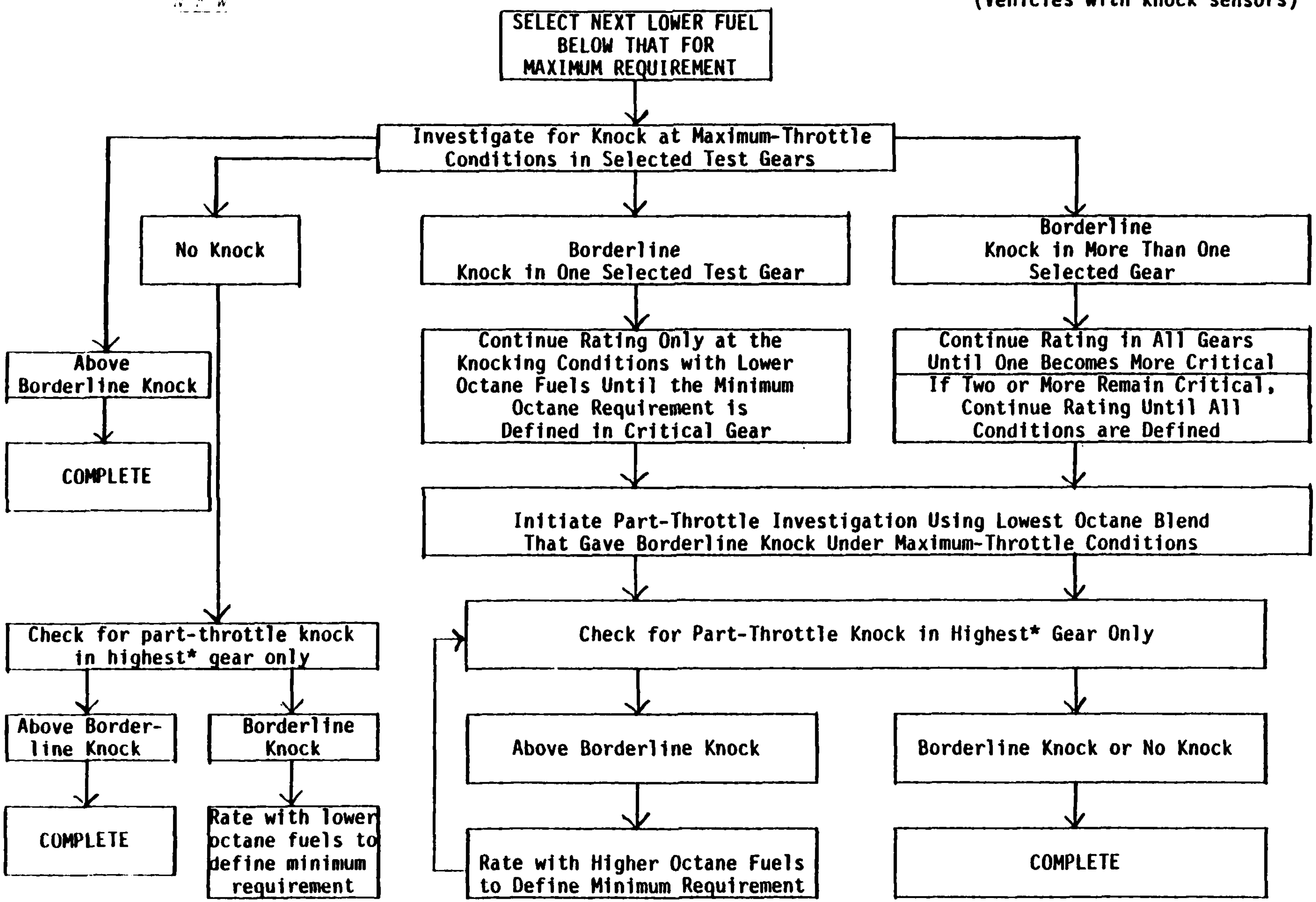
It is important that the vehicle identification number (VIN) of each vehicle tested be recorded on all data sheets to provide a means of cross-indexing.



* See D.3.d.(1)(a), Pages C-7 and C-8.

N E W

FOR ESTABLISHING MINIMUM REQUIREMENTS
(Vehicles with knock sensors)



* See D.3.d.(1)(a), Pages C-7 and C-8.

ATTACHMENT A

to the

CRC E-15-84 TECHNIQUE

PROCEDURE FOR SETTING UP VEHICLES

WITH FUEL INJECTION

ATTACHMENT A

TO THE CRC E-15- 84 TECHNIQUE

PROCEDURE FOR SETTING UP VEHICLES AND HANDLING REFERENCE FUELS -- VEHICLES EQUIPPED WITH MULTIPLE-PORT FUEL INJECTION

1. To run octane requirements on fuel-injected vehicles it is necessary to run an external fuel line to the inlet of the vehicle fuel injection pump.

2. The fuel return line from the engine to the fuel tank must be disconnected after the fuel pressure regulator (in engine compartment) and before the fuel tank. An auxiliary line long enough to reach the cans must be added to the fuel return line.

3. Make certain that the fuel tank connections are plugged; this means both the normal fuel pump inlet line and the normal fuel return line connection. On vehicles with an in-tank booster pump, this pump must be shut off so it cannot run during the time the vehicle is operating on the external fuel system. If this pump is not disconnected, it will be destroyed.

4. An electric fuel pump (Bendix type acceptable) must be used to draw fuel from the reference fuel can to supply the fuel injection pump on the vehicle. Caution must be exercised to keep the fuel line between the reference fuel cans and the vehicle fuel injection pump full of fuel. If very much air gets into this line, the fuel injection system will become air bound and it is difficult to get the air out of the system.

5. Once the fuel injection pump line and return line have been disconnected, all subsequent operations must be done from an external fuel source.

6. It is possible to use three-way valves in the fuel line between the fuel pump and the fuel tank and between the return line and the fuel tank. When used, the operator must change the return line valve to the auxiliary fuel system while the engine is shut down, to avoid building up excessive pressure in the return line which could damage both the fuel pressure regulator and injection pump.

7. When changing from one reference fuel to another, the following steps must be followed:

   a. Put fuel inlet line in reference fuel tank with the return line going to a slop fuel can. Do not keep fuel inlet line out of the fuel can any longer than is necessary to move it from one can to the next. DO NOT RUN OUT OF FUEL.

b. Observe the fuel stream in the fuel return line. As soon as a steady flow of fuel is observed, move the fuel return line to an empty one-quart can (0.946 ℓ). Allow one quart (0.946 ℓ) of fuel to flow into this can before inserting the return line into the chosen reference fuel can. This operation should take about 60 seconds.

c. When going to the next reference fuel, it will be necessary to repeat Steps a and b.

The fuel injection pumps on most vehicles pump between 30 and 50 gallons (114-189 ℓ/h) of fuel per hour. Therefore, Steps a and b should be folowed very closely or there will be gross reference fuel contamination, or you will use a lot more reference fuel than is required to run each test. If Steps a and b are followed exactly, you will be discarding to slop about two quarts (1.892 ℓ) of reference fuel each time you change reference fuels. The two quarts (1.892 ℓ) to slop will be at least as much fuel as is consumed to obtain the reference fuel rating.

CAUTION

For high-pressure fuel systems, be sure to relieve the pressure before disconnecting fuel lines. Also, use auxiliary fuel lines designed for high pressure. The engine and auxiliary fuel pump should be shut off while changing from auxiliary to tank fuels.

Diagnostic scanners should not be used while knock testing.

Auxiliary hoses should be rated for at least 250 psi working pressure and 1000 psi burst pressure.

PROCEDURE FOR SETTING UP VEHICLES AND HANDLING REFERENCE FUELS -- VEHICLES EQUIPPED WITH THROTTLE-BODY FUEL INJECTION

The General Motors throttle-body fuel injection system is shown in the attached schematic drawing. The fuel supply system consists of an in-tank electric fuel pump, a full-flow fuel filter mounted on the vehicle frame, a fuel pressure regulator integral with the throttle body, fuel supply and return lines, and two fuel injectors. The injection timing and amount of fuel supplied is controlled by an electronic control module (not shown in figure). To prepare a vehicle with this system for octane requirement testing, an auxiliary electric fuel pump must be installed. The fuel pressure regulator controls fuel pressure at the injectors to a nominal 10.5 psi; therefore, an auxiliary pump capable of at least 10.5 psi outlet pressure must be used for satisfactory engine operation. The following procedure is recommended for preparing a vehicle with throttle-body fuel injection for octane requirement testing and for changing reference fuels during such testing:

1. Disconnect and plug the fuel supply and fuel return lines at the locations shown in the figure. Install an additional line between the fuel supply line and the outlet of the auxiliary pump. Connect the inlet of the auxiliary pump to the reference fuel can. Connect the fuel return line to the reference fuel can through a tee at the auxiliary pump inlet. All auxiliary fuel lines are indicated by dashed lines in the figure.

2. An optional arrangement would be to use three-way selector valves in the fuel supply and fuel return lines at the locations where auxiliary fuel lines are connected. When these valves are used, the operator must change the valves to the external fuel system while the engine is shut off to avoid building up excessive pressure in the fuel return line.

3. Disconnect the in-tank fuel pump so it cannot run during the time the vehicle is operating on the external fuel system. If this pump is not disconnected, it may be destroyed.

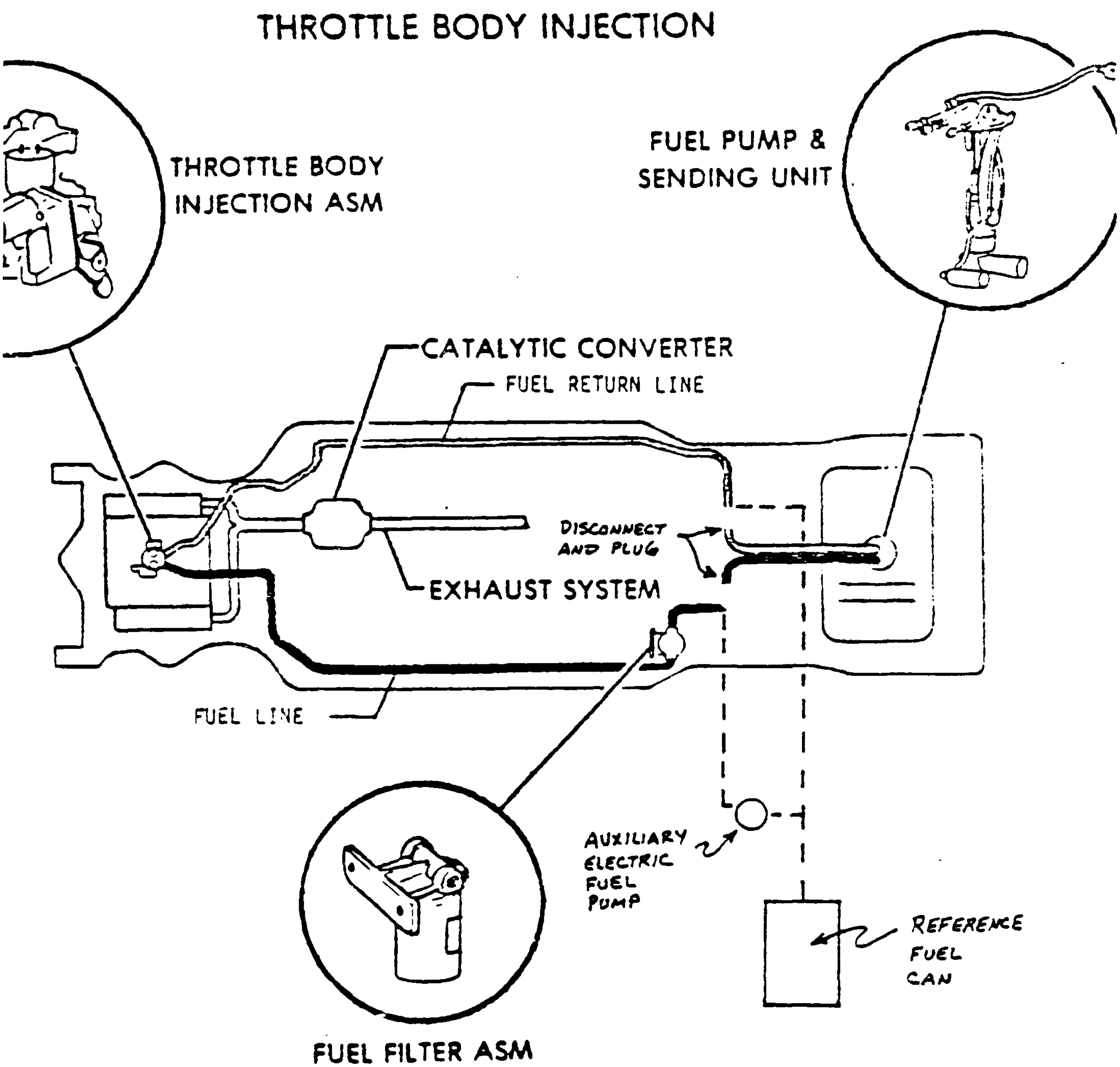
4. When changing from one reference fuel to another, the following steps should be followed:

   a. Disconnect fuel inlet line from reference fuel can and run engine a short time; <u>do not run out of fuel</u> since this will introduce air into the fuel injection system, and excessive cranking will be required to restart the engine.

   b. Insert fuel inlet line in desired reference fuel can; operate vehicle for two miles at a maximum speed of 55 mph during which time four part-throttle accelerations are made. This must be done to ensure that the vehicle fuel system has been purged and contains the desired reference fuel for octane rating.

   c. When changing to another reference fuel, repeat Steps a and b.

PROCEDURE FOR SETTING UP VEHICLES AND HANDLING REFERENCE FUELS
-- VEHICLES EQUIPPED WITH THROTTLE-BODY FUEL INJECTION - (Continued)



PROCEDURE FOR SETTING UP VEHICLES AND HANDLING REFERENCE FUELS -- FORD VEHICLES EQUIPPED WITH CENTRAL FUEL INJECTION SYSTEM

A vehicle schematic of one of Ford's central fuel injection systems is shown on the following drawing (other systems vary in configuration dependent upon engine/model type - see note 1). This fuel system consists of: an electric in-tank fuel pump, primary and secondary full-flow fuel filters, throttle-body assembly with integral fuel pressure regulator and two fuel injectors, fuel supply and return lines. The following procedure is recommended for preparing the vehicle for octane requirement testing:

1. Relieve pressure in fuel system using valve provided on throttle body. Fuel supply lines will remain pressurized for long periods of time after engine shut down. Disconnect and cap the fuel supply and fuel return lines leading from the fuel tank. Access to connection points may be obtained through either the: rear wheel wells, underbody, or engine compartment, dependent upon vehicle type. Install additional lines to the open supply and return lines and lead these lines back into the vehicle.

2. Connect the added fuel supply line to an auxiliary fuel pump. The fuel pressure regulator in the throttle body controls fuel pressure to a nominal 39.9 psi; therefore, it requires an auxiliary fuel pump capable of providing at least 45 psi outlet pressure (see note 1). The added 5.1 psi is needed to sufficiently overcome the pressure head and line restriction losses. Connect a supply line to the auxiliary pump from the reference fuel can. A fuel filter may be required between the auxiliary pump and reference fuel can to protect the pump. Also, connect the added fuel return line to the fuel reference can and vent the reference can to outside the vehicle.

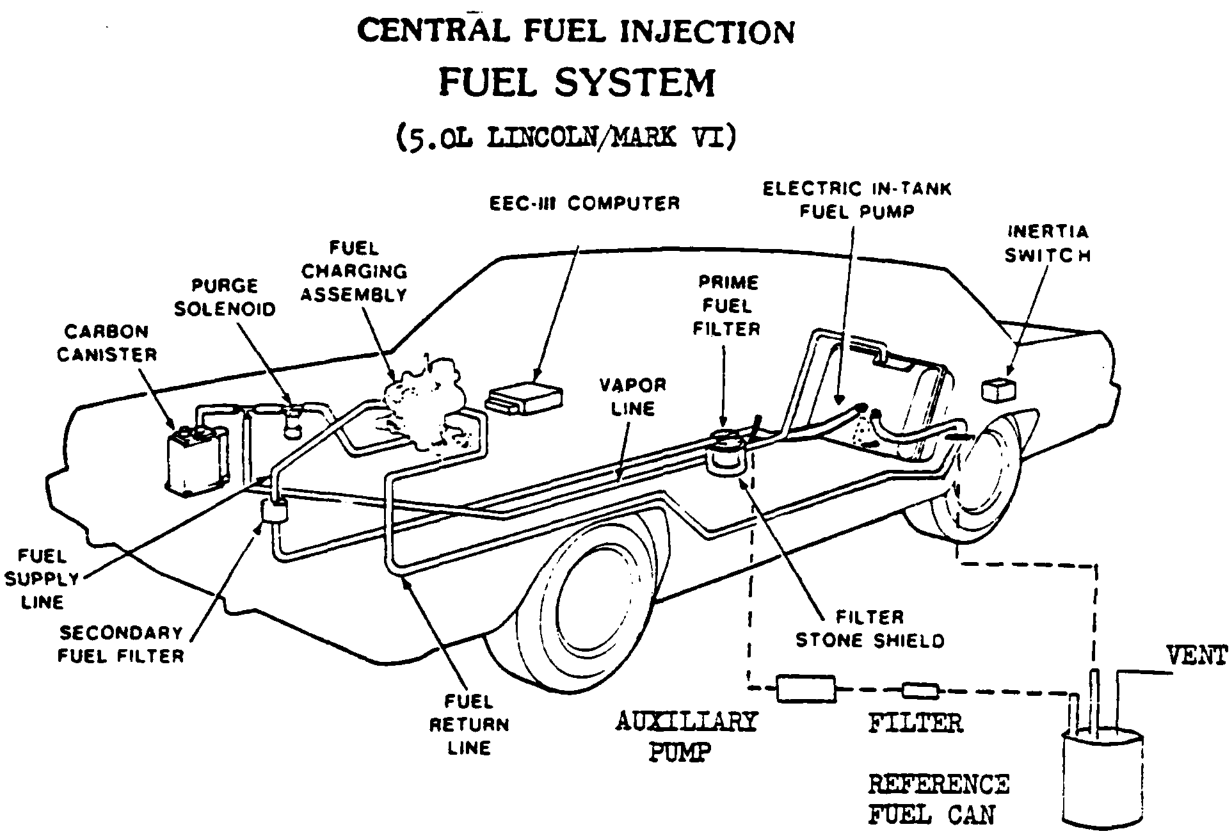
3. Disconnect the electrical supply to the electric in-tank fuel pump, either by disconnecting the plug on the fuel tank or by disarming the inertia switch located in the trunk. Failure to disarm the in-tank fuel pump may result in a damaged pump. The voltage supplied to the inertia switch may be used as an electrical source for the auxiliary fuel pump. This voltage source is controlled by the on-board computer allowing the auxiliary pump to respond the same as would the in-tank fuel pump. When making this connection, do not "splice" into the wire, instead connect the wire lead to the connector.

4. When changing from one reference fuel to another, the following steps should be followed, or else reference fuels may become contaminated:

   a. With the engine shut off, disconnect the fuel return line from the reference fuel can and connect it to an extra empty can. Connect the fuel pump supply line to the new reference fuel can and run the engine for approximately 30 seconds, purging the old reference fuel into the extra can (timing is dependent upon length of added fuel lines). After the sytem is purged, shut the engine off and connect the fuel return line to the new reference fuel can forming a closed fuel loop. Now the vehicle is ready to be tested on the desired reference fuel.

   b. When changing to another reference fuel, repeat Step a.

PROCEDURE FOR SETTING UP VEHICLES AND HANDLING REFERENCE FUELS
-- FORD VEHICLES EQUIPPED WITH CENTRAL FUEL INJECTION SYSTEM - (Continued)



1/ NOTE:

Some vehicles have both a low pressure in-tank fuel pump and a high pressure under body fuel pump. The on-board high pressure pump may be used if supplied with an auxiliary pump. In all cases, it is required that on-board pumps not used, be disarmed. The inertia switch located in the rear of the vehicle will disarm both pumps. Fuel lines on some vehicles may be accessed only in the engine compartment, or by dropping the fuel tank.

APPENDIX D

RECOMMENDED MODIFICATIONS TO

CRC OCTANE NUMBER REQUIREMENT RATING FORM DFMF-11-1184

DFMF-11-1184

1984 CRC OCTANE NUMBER REQUIREMENT SURVEY – 1984 MODEL VEHICLES

Company ____________ Test Location: Road ____ Chassis ______ Sheet ____ of ____ Sheets

For detailed questions contact: Name ____________ Date ______

Telephone ____________ Driver ____________ Observer ______

Vehicle Make ________ Model ________ No. of Cyl. ______ ~~Brake HP~~

V.I.N. ____________ License No. ____________ Engine Cal. (Ford) ______

(MOVE)

Converter Clutch Application

Vacuum ____________

MPH ____________

ELIMINATE:

Transmission Downshift Characteristics		
MPH	RPM	Man. Vac.
25		
35		
45		
55		

Road Load			
MPH	VAC	MPH	VAC
25		45	
35		55	

TO BE FILLED IN BY CRC: Obs. No.	Lab Code	Vehicle Code	VEHICLE: Emission Cert (1)	Induction (2)	Carb. Bbls (3)	Displacement Liters	Knock (4)	Sensor (5)	Compression Ratio	Transmission (6)	(7)	Air Cond. (4)	Spark Advance °BTDC (8): As Received	As Tested	Odometer Miles	WEATHER: Amb. Temp. °F	Barometer " Hg.	Humidity Gr./Lb.	Card No.	Cust. Knock (9)	TANK FUEL DATA: Research Octane Number	Motor Octane Number
1 2 3	4 5	6 7 8 9	10	11	12	13 14	15	16	17 18 19	20	21	22	23 24 25	26 27 28	29 30 31 32 33	34 35 36	37 38 39 40	41 42 43	44	45	46 47 48 49	50 51 52 53
																			1			

CARD 1 (CONTINUED)

RATER T.F. REPORT: Knock Intensity (10)	Noise Type (11)	Test Gear No.	RPM of Max. Knock Intensity	Man. Vac. " Hg. /psi	FOR USE BY CRC
54 55	56	57	58 59 60	61 62 63	64 65 66 67 68 69 70 71 72

ADD BOX FOR "THROTTLE (12)"

OCTANE NUMBER REQUIREMENTS

Fuel	Card No.	MAXIMUM: Throttle (12)	Research Octane Number (13)	Noise Type (11)	Test Gear No.	RPM of Maximum Knock Intensity	Man. Vac. " Hg. /psi	PART-THROTTLE TECHNIQUE: Research Octane Number (13, 14)	Noise Type (11)	Test Gear No.	RPM of Maximum Knock Intensity	Man. Vac. " Hg. /psi	
	44	45	46 47 48 49	50	51	52 53 54 55	56 57 58	59 60 61 62	63	64	65 66 67 68	69 70 71	72
FBRU	2												
FBRSU	3												
PRF	4												

ADD BOX FOR "CONV. CLUTCH" ADD DECIMAL POINT

Reference Fuel: Series	Res. O.N.	Test Gear No.	Intake Manifold Vac. (In HG)	Max. Knock Intensity (10) Acceleration: 1	2	3	(10) Final Rating	RPM of Max. Knock Intensity	Speed Range, RPM: Knock In	Knock Out	Type (11) of Knock
								(MOVE)			

(1) F = Federal; C = California; A = Altitude; B = "C" and "A"

(2) V = Variable Venturi; T = Turbocharged

(3) Number of Carb. Venturi or F for fuel injection

(4) Y = Yes; N = No

(5) If Column 4 is Y, record H = Higher Req.; L = Lower Req. Use second sheet for lower (L) requirement. Repeat only company and VIN in heading.

(6) A = Automatic; M = Manual

(7) Record number of transmission speeds

(8) Columns 23 and 26: + = BTDC, – = ATDC

(9) Y = Yes; N = No; O = Objectionable

(10) N = None; B = Borderline; A = Above Borderline

(11) K = Spark Knock, S = Surface Ignition; B = Both K and S

(12) M = Maximum Throttle; P = Part Throttle Higher than Maximum Throttle Requirement

(13) Columns 46 and 59: L = Less than lowest available fuel; H = Higher than highest available fuel

(14) If part-throttle requirement is greater than four numbers below maximum throttle requirement enter letter P

END

FILMED

8-85

DTIC