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# 1992 CRC OCTANE NUMBER REQUIREMENT RATING WORKSHOP



October 1992



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

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# 1992 CRC OCTANE NUMBER REQUIREMENT RATING WORKSHOP

(CRC PROJECT NO. CM-124-92)



Prepared by the

CRC Octane Technology and Test Procedures Group



October 1992

Automotive Vehicle Fuel, Lubricant, and Equipment Research Committee

of the

Coordinating Research Council, Inc.

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**APPENDICES**

# I. INTRODUCTION

An octane number requirement rating workshop was sponsored by the Coordinating Research Council, Inc. May 18-22, 1992 in Brooklyn, Michigan at the Michigan International Speedway. The workshop was conducted in response to a request by the CRC Octane Technology and Test Procedures Group. Forty raters, technicians, and engineers attended all or part of the workshop. Attendees are listed in Appendix A. The workshop consisted of track practice and classroom sessions including seminars, extensive discussions, and presentations from OEM and equipment manufacturer experts. A workshop program proposal and agenda are included in Appendix B.

# II. OBJECTIVE

The objective of the workshop was to improve the application of the CRC E-15 Technique for Determination of Octane Number Requirement of Light-Duty Vehicles, given in Appendix C. As attendees had various levels of experience with the E-15 Technique, the workshop was to improve the skills of those with minimal experience and provide experienced raters a forum for interacting with other raters of similar experience. Investigative procedures and techniques were encouraged to provide data regarding the latest electronic engine controls such as knock sensors and adaptive learning strategies.

Since the workshop was to be an educational experience rather than a designed test program to provide octane number requirement data for the Octane Number Requirement Survey (ONRS), emphasis was placed on interaction within the group to identify areas of common concern and discussing these concerns as a group. Experts from several sources provided information to address many of these concerns.

# III. TEST VEHICLES

Eleven 1991 and 1992 model year vehicles were used for track practice and testing. The vehicles are shown in Table 1. Five of the vehicles were equipped with auxiliary fuel systems to allow operation on the octane number reference fuels. The other six vehicles were equipped with tachometers and vacuum gauges for determination of transmission shift characteristics. Several scan tools were available and were used on most of the GM vehicles to monitor knock sensor activity and spark timing.

## IV. TEST FUELS

The test fuels used during the workshop were full-boiling range unleaded (FBRU) fuels from the 1990-91 Customer/Rater Program. Reference fuels were blended in two number increments from 78 Research octane number (RON) to 102 RON. Detailed fuel data is not provided as these fuels were used only to practice the E-15 Technique, and no ONR data were developed to supplement any existing ONRS data.

## V. TEST PROGRAM

The workshop was conducted May 18-22, 1992, at Michigan International Speedway in Brooklyn, Michigan. The timing of the workshop was such that the information and skills would benefit the 1992 CRC Octane Number Requirement Survey. The workshop was designed to optimize on-track E-15 Technique practice, highlighted by appropriate discussions regarding vehicle control systems and procedural issues such as proper completion of data sheets and new changes to the procedure. Questions and comments from the participants were encouraged.

The first day of the workshop was devoted to preparing the vehicles for testing. A representative from Snap-On Tools Corporation exhibited a comprehensive assortment of fuel system fittings and tools and demonstrated a scan tool. After this exhibition, several groups connected auxiliary fuel systems to five of the vehicles. The hands-on experience and informal discussions while working on the vehicles provided excellent training.

On the second day, a knock-sensor exercise was introduced to encourage those participants unfamiliar with scan tools and the GM knock sensor to gain an understanding of the operation of the knock sensor. A presentation by Clayton Dynamometer described the operation of chassis dynamometers. Handouts from this presentation are provided in Appendix D. After on-track E-15 Technique practice, the history of the Octane Number Requirement Survey and the "505 Warm-Up Cycle" were discussed.

The third day continued E-15 Technique practice, with presentations from Chrysler and Ford. An engine-calibration engineer from Chrysler discussed the development process for knock sensors and their application. This presentation is attached as Appendix E. A transmission-control engineer from Ford Motor Company described automatic transmission operation, calibration of shift points, the use of a torque converter clutch, and the increasing use of electronic controls. This presentation is attached as Appendix F. Data from the 1991 ONRS was discussed, comparing the full-boiling range unleaded (FBRU) fuels to the FBRU fuels containing methyl tertiary butyl ether (MTBE), denoted as FBRUM fuels. No difference in vehicle octane number response was seen; however, this finding will be confirmed in the 1992 ONRS.

A small group of experienced raters evaluated the operation of the Saturn with adaptive ignition timing. Another small group of experienced raters evaluated the knock-sensor sensitivity on the Bonneville. An octane number requirement was measured on the Town Car with and without the evaporative fuel canister connected.

The fourth day included a presentation from a Ford Motor Company knock-sensor development engineer. This presentation is attached as Appendix G. On-track practice continued following the presentation. The octane number requirement of the Town Car was determined with and without the octane adjust plug connected, which, when removed, retards spark timing 3 degrees. The vehicles which were set-up with auxiliary fuel systems were returned to their stock configuration during the afternoon.

The final day of the workshop addressed issues that had arisen during the week. A summary of the data is discussed in the "Analysis and Discussion of Data" section of this report. Suggestions and issues raised during these discussions are summarized in the "Recommendations For Improving the E-15 Technique" section of this report.

## VI. ANALYSIS AND DISCUSSION OF DATA

Several brief experiments were made during the workshop to address evaporative fuel canister effect on octane number requirement (ONR), effect of knock sensors on ignition timing and ONR, and ignition timing retard effect on ONR. These data will not be included in the 1991 or 1992 ONRS since, in most cases, the E-15 Technique was not completely executed and the reference fuels were not identical to those used for the ONRS. Certain portions of the E-15 Technique were used to expedite the experiments and to provide only the results relevant for the particular experiment. As these experiments were cursory, the results should be treated as such.

The Town Car was used to determine the evaporative fuel canister effect on the ONR. On the morning of the third day, the vacuum port on the intake manifold to the evaporative fuel canister was plugged. The vehicle was operated for about two hours followed by a hot soak for about an hour at 75°F. By disabling the purge of the evaporative emissions system, there was an attempt to "load" the canister. After lunch, the ONR was determined with the vacuum port still plugged. The vehicle was operated on the ONR fuel while knock intensity and critical engine operating conditions were noted. The evaporative fuel line was reconnected to the manifold. The knock intensity and critical engine operating conditions were again noted. The ONR of the vehicle, knock intensity, nor critical knocking conditions were affected by reconnecting the evaporative fuel canister.

A scan tool (OTC 4000) was connected to the Bonneville to monitor knock-sensor signal, knock-sensor spark retard, and engine spark advance. The vehicle was wired to allow engine operation with the engine block-mounted knock sensor or a remote knock sensor isolated from engine block. Data are shown in Appendix H from the second and third days of the workshop. ONR was determined with the knock sensor operational (KS on) and with the remote knock sensor off (KS off). On the second day of the workshop (5-19-92), the highest octane number fuel run in this vehicle with the knock sensor off was 92 RON. This fuel exhibited above-borderline knock. On the following day with the knock sensor on, the vehicle exhibited no audible knock on 92 RON fuel; however, the scan tool indicated some knock-sensor activity, with 1-2 degrees of spark retard. As lower octane number fuels were run, larger amounts of spark retard were shown on the scan tool. No audible knock was detected until 84 RON. This fuel was at least 8 numbers lower than the knock-sensor-off ONR. An interpretation of the data suggests the ONR with the knock sensor off probably would have been about 93 RON. Above-borderline knock was detected at 82 RON with the knock sensor on. With the 82 RON fuel, the scan tool showed 6 degrees of spark retard, which is most likely the maximum amount of retard the knock-sensor system can provide. Spark advance was 17 degrees with the 92 RON fuel and 10 degrees with the 82 RON fuel. The base calibrated spark timing seemed to be 17 degrees since adding the amount of retard to the spark advance seen on the scan tool with the 82 RON fuel almost equaled the advance seen with the 92 RON fuel.

A scan tool (Snap On MT 2500) was connected to the Saturn SC. Similar to the Bonneville, knock-sensor spark retard and engine spark advance could be viewed. The spark-timing system on this vehicle is adaptive. Not only could spark timing be retarded for individual occurrences of knock, the base calibrated spark could be retarded if frequent occurrences of knock were detected. Based on comments from the participants operating this vehicle, ONR of the Saturn could be more easily determined than the Bonneville, because of the spark-timing system. The Bonneville knock-sensor system seemed to be calibrated to react at a much lower threshold of knock. The Saturn, when operated for extended periods on a knocking fuel, would adjust spark timing to minimize audible knock. Readjusting spark timing to a somewhat higher octane fuel would also require extended operation. Conversely, the Bonneville merely retarded spark sufficiently to minimize audible knock. Calibrated spark timing was only affected when the engine was knocking and maximum calibrated spark advance was restored virtually as soon as no knock was encountered. To minimize the effects of the adaptive spark timing system on the Saturn, the participants operating this vehicle recommended starting with a sufficiently high octane number fuel and descending to the ONR and to avoid operating the vehicle at knocking conditions for any length of time.

The Town Car was equipped with an octane adjust plug. When the plug is removed, base ignition timing is retarded by 3 degrees. The ONR was determined with and without the plug installed. The ONR was 93 RON with the plug installed and 89 RON with the plug removed. Critical operating conditions and knock intensity ranges were similar in both situations. Although odd-number octane fuels were not available, the even-numbered fuels were used to bracket the ONR.

## VII. RECOMMENDATIONS FOR IMPROVING THE E-15 TECHNIQUE

The Octane Technology and Test Procedures Group has requested recommendations from this workshop to enhance the current E-15 Technique. Because of the increased complexity of engine-control systems, specifically the aggressive use of knock sensors, determining vehicle ONR has become rather difficult. On the last day of the workshop, an open discussion provided many suggestions. The suggestions are outlined below:

- The definition of minimum attainable road speed needs to be clarified. Typically, the lowest attainable transmission downshift speeds are slightly lower than the upshift speeds. Both situations could be argued representative of customer operation.

- Nomenclature for transmission torque converter clutch state (locked or unlocked) may be difficult to determine on electronically-controlled transmissions with modulated engagement.

- Several laboratories are using scan tools while running in-house ONR tests and are comfortable that these tools do not effect ONR. The scan tools are typically used for quality control; for example, ensuring engine is at operating temperature and in closed-loop fuel control. A suggestion was made to allow the use of scan tools for this purpose.

- When reporting test data, more than one form of side C and D are used. It was suggested that separate pads be provided for the forms of side A and B and the forms of side C and D.

- The issue of slave evaporative fuel canisters was discussed at length. The proper canisters are difficult to obtain and may be connected improperly, as there may be calibrated orifices throughout the system. Ford has conducted limited testing that has indicated canister loading does not affect ONR of Ford vehicles. Also, a cursory experiment at this workshop did not indicate a measurable effect. It was suggested that further data be developed to determine canister loading effects on ONR.

- The 505-second warm-up preconditioning cycle (first 505 seconds of the Federal Tert Procedure exhaust emissions test cycle, also referred to as "Bag 1") was found to be difficult to perform for some laboratories due to hardware constraints. Other laboratories have summarized the maneuvers of the 505 cycle by time and speeds for accelerations, decelerations, and cruises. These laboratories felt a transient cycle closely resembling the 505 cycle would be adequate. An alternative but similar time/speed cycle should be included in the E-15 Technique.

- The definition of vehicle ONR may need to be redefined necessitated by the aggressive use of knock sensors. In the Bonneville, the knock sensor detected knock and began to retard spark timing several octane numbers higher than audible knock was detected. On vehicles with knock sensors, the knock-sensor system may be used for determining knock. It was proposed that ONR would be the highest octane number fuel that causes perhaps 2 degrees of retard as shown by a scan tool.

- For vehicles with adaptive spark-timing systems (some GM and Chrysler vehicles, perhaps others), warm-up and preconditions should be run with a sufficiently high octane number fuel to avoid knock. When determining ONR, the first fuel should be sufficiently high to avoid knock and descend to the ONR. Operate the vehicle at knocking conditions during rating as little as possible.

## VIII. RECOMMENDATIONS FOR FUTURE RATING WORKSHOPS

The consensus of the participants was that a rating workshop should be held at least every two years as automotive technology is rapidly changing. The format used, with much time devoted to hands-on, track practice of E-15 Techniques supplemented by brief meetings and presentations, was found to provide a comfortable environment for participation and learning. Since there are many questions regarding the safety and functional aspects of vehicle set-up, devoting most of the first day to address this procedure is necessary. The participants found this time to be useful for discussing specifics of vehicle set-up such as fuel pumps, fittings, fuel handling, and scan tool diagnostic capability. Three days were made available for track practice in which meeting time was minimized. Questions were addressed by either small informal groups or recorded for later discussion. Inviting experts on various relevant subjects was found to be an excellent aid to provide accurate information. The final day was entirely devoted to discussion of issues that surfaced during the week, to share individual experiences, and to formulate suggestions for improving the E-15 Technique and future workshops.

In order for the set-up day to be beneficial, arrangements must be made prior to the workshop for participants to provide fuel systems for a particular vehicle. Since several different vehicle makes were available for set-up, participants were encouraged to discuss and participate in the set-up of the vehicle of their choice. Comparison of several different scan tools may be held concurrently with the set-up of the vehicle of most interest. Sufficient reference fuel cans should be provided to allow a can to be dedicated to a particular octane number. The reference fuel cans were filled from 16-gallon drums of reference fuels blended prior to the workshop. This arrangement alleviated the inconvenience of blending reference fuels on-site prior to or during the workshop or excessive fuel handling during the workshop.

During track practice, groups of three to four participants with varying levels of experience were formed and were rotated through the available vehicles. These groups were changed periodically throughout the workshop. These assignments were found beneficial to those with less experience, and the more experienced raters appreciated the opportunity to evaluate the various vehicles.

The facility is an important part of the success of the workshop. Although this track was about 35 minutes from the hotel, the meeting and garage facilities were excellent. The meeting area was a hospitality suite, which was quiet and comfortable and allowed a view of the track. The garage area was clean and very large. The track, although banked rather steep, was sufficiently long (2 miles) and wide to allow a level of safety even with eleven vehicles on the track at once. While at the track, lunch was catered due to limited availability of local restaurants.

Table 1

Test Vehicles

| Year/Make/Model | Engine Displacement | Fuel Delivery[1] | Knock Sensor | Transmission[2] | Aux. Fuel System |
|---|---|---|---|---|---|
| 1991 Acura Legend[3] | 3.3L | PFI | Yes | 4 speed auto | Yes |
| 1992 Cadillac Coupe de Ville[4] | 4.9L | PFI | Yes | 4 speed auto | No |
| 1992 Chrysler New Yorker[4] | 3.3L | PFI | No | 4 speed auto | No |
| 1992 Ford Ranger[5] | 3.0L | PFI | No | 4 speed auto | No |
| 1992 Ford Thunderbird S/C[5] | 3.8L | PFI | Yes | 4 speed auto | Yes |
| 1992 Ford E-150[5] | 5.8L | PFI | No | 4 speed auto | No |
| 1991 Lincoln Town Car[5] | 4.6L | PFI | No | 4 speed auto | Yes |
| 1992 Oldsmobile Delta 88[4] | 3.8L | PFI | Yes | 4 speed auto | No |
| 1992 Pontiac Bonneville[4] | 3.8L | PFI | Yes | 4 speed auto | Yes |
| 1992 Pontiac Grand Am[4] | 2.3L | PFI | Yes | 4 speed auto | No |
| 1992 Saturn SC[6] | 1.9L | PFI | Yes | 4 speed auto | Yes |

[1] PFI = port fuel injection

[2] Every transmission had a torque converter clutch

[3] Provided by Amoco Oil Company

[4] Obtained from rental agencies

[5] Provided by Ford Motor Company

[6] Provided by General Motors

# APPENDIX A

## WORKSHOP ATTENDEES

# PARTICIPANTS IN 1992
# CRC OCTANE NUMBER REQUIREMENT RATING WORKSHOP

| NAME | COMPANY AFFILIATION |
|---|---|
| Les Bostick | Ashland Petroleum |
| Mike Briggs | BP Research |
| Greg Brooks | Unocal |
| Jim Callison | Amoco Oil Company |
| Craig Carlson | Ford Motor Company |
| Linda Caspermeyer | Mobil R & D |
| Dennis Clancy | Ford Motor Company |
| Paul Czaja | Southwest Research Institute |
| Gregory Dykstra | Chrysler Motors |
| Murray Dent | Shell Canada Ltd. |
| Jimmie Douglass | Shell Development Company |
| Dale Esper | Ford Motor Company |
| Beth Evans | Coordinating Research Council |
| Kurt Groll | Texaco, Inc. |
| Bruce Henderson | Amoco Oil Company |
| Carl Johnson | Texaco, Inc. |
| Eddie Jones | Phillips Petroleum Co. |
| John Konarski | Ford Motor Company |
| Steve Kraft | AutoResearch Labs |
| James Langworthy | Mobil R & D |
| John Lawrie | BP Research |
| Tim Mayhew | Shell Canada |
| Martin Megnin | Texaco, Inc. |
| Kirk Mellits | Snap-On |
| William Miller | Ford Motor Company |
| Tom Orto | Ford Motor Company |
| Bruce Palansky | Ford Motor Company |
| Gary Parker | Exxon R & E |
| Greg Pawezuk | Ford Motor Company |
| Stanley Pilling | Sun R&M |
| Mike Rivenburgh | E G & G Automotive |
| Dave Sharp | AutoResearch Labs |
| John Straw | Phillips Petroleum Co. |
| Richard Tither | Mobil Oil Corp. |
| Peter Van Slyke | Chevron Research & Technology |
| James P. Warren | Shell Development |
| Scott Whitehouse | Shell Canada |
| Francis Witkus | Exxon R & E |
| Tim Wusz | Unocal |
| Ben Wyatt | E G & G Automotive |

# APPENDIX B

## PROGRAM AND AGENDA FOR THE 1992 CRC OCTANE NUMBER REQUIREMENT RATING WORKSHOP

# PROGRAM FOR THE 1992 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 1989 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 years.

The CRC Octane Technology and Test Procedures Group decided to conduct another rating workshop which would emphasize vehicle preparation, the evaluation of vehicles equipped with knock sensors, and the evaluation of vehicles equipped with adaptive learning capabilities. The preferred time for the workshop is the spring of 1992, so that the results could be used for the 1992 CRC Octane Number Requirement Survey.

## II. OBJECTIVE

The objective of this workshop is to improve the application of the E-15 Procedure.

## III. SCOPE AND TIMING

Training will be accomplished through seminars, discussions and demonstrations, and verified with actual track testing using rating techniques and equipment. The workshop will be held May 18-22, 1992.

## IV. FACILITIES

Ideally, the workshop should include both track testing and dynamometer testing. Unfortunately, such a facility could not be located. The workshop will be held at Michigan International Speedway near Jackson, Michigan. This facility has a 2-mile oval track which is suitable for road octane testing. Garage space is available for vehicle preparation and meeting facilities can be provided in a convenient location. Lunches will be provided on-site consisting of a sandwich bar, salads, and beverages.

## V. VEHICLES

Approximately twelve 1992 model-year vehicles will be used. The group should include vehicles with one or more of the following features: spark adjustment by a knock sensor system, direct fire ignition, transmissions which experience indicates are difficult to rate, supercharger, electronically controlled transmissions, and continuously variable automatic transmission. Approximately four of the vehicles will be set up with auxiliary fuels systems for full vacuum gauge and tachometer and will be used to sharpen skills used in determining vehicle transmission characteristics.

## VI. FUELS

The fuel used will be drawn from the 1990/1991 FBRCU rating series used in the 1990/1991 CRC Customer/Rater Octane Number Requirement Program. It will be available in two octane number increments. Since the Customer/Rater ONR Program is complete, the fuels can be made available by workshop participants from their excess stock.

## VI. WORKSHOP SCHEDULE

The Workshop will run from Monday through Friday.

The simplified, proposed schedule follows:

| | |
|---|---|
| Day 1, | Vehicle set-up, discussion and practice. |
| Day 2,3 | Discussion and demonstration of E-15 Procedure mixing experienced and inexperienced raters. |
| Day 4 | Experienced raters discuss E-15. |
| Day 5 | Wrap-up. |

## VIII. PARTICIPATION

The workshop has been planned on the basis of the following participation by each company: (1) an engineer responsible for E-15 activities; (2) a rating crew, preferably experienced; and (3) if the rating does not prepare vehicles, one mechanic familiar with vehicle preparation. If multiple crews are sent, one engineer should be sufficient.

The engineering personnel will be expected to participate in the discussion, monitor test procedures in the cars and help with the E-15 Technique, and handle the logistics of the operation. Time permitting, they may also participate in the demonstrations and testing.

A significant amount of planning, preparation, and coordination will be required to assure success of the workshop. Major activities needing attention are listed below:

- Overall coordination during workshop
- Group sessions: planning and conduct
- Track preparations and operations
- Test equipment
- Test vehicles: procurement
- Test fuels: procurement of fuels and cans and coordination of on-site handling

## Coordinating Research Council 1992 ONR Raters Workshop

| | MONDAY 5/18 | TUESDAY 5/19 | WEDNESDAY 5/20 | THURSDAY 5/21 | FRIDAY 5/22 |
|---|---|---|---|---|---|
| 8:00 | Meet in Hotel Lobby | | | | |
| 8:30 | Arrive at MIS | Arrive at MIS | Arrive at MIS | Arrive at MIS | Meet in Hotel Conference |
| | Opening Comments | Track Orientation | Discuss Data Sheets | Discuss Data Sheets | Room |
| 9:00 | Snap-On Presentation | Clayton Presentation | Open Discussion | Ford Presentation | Wrap-up Discussion |
| | Mr. Kirk Mellits | Mr. Brooke Lammot | Practice E-15 Procedure | KS Applications | Discuss GM Knock |
| 9:30 | Fuel System Tools | How chassis dynos work | | Mr. Scott Sabin | Sensor Results |
| | Scan Tool Demo | | | | |
| 10:00 | Vehicle Setup | Practice E-15 Procedure | | Practice E-15 Procedure | |
| 10:30 | | | Chrysler Presentation | | |
| | | | KS/other | | |
| 11:00 | | | Mr. Greg Dykstra | | Adjourn |
| 11:30 | Lunch | Lunch | Lunch | Lunch | |
| 12:30 | Continue Vehicle Setup | Historical Perspective | Ford Presentation | Practice E-15 Procedure | |
| | | Future Surveys | Auto Transmissions | | |
| 1:00 | | Data Sheets | Mr. Bruce Palansky | | |
| | | Mr. James Callison (Amoco) | | | |
| 1:30 | | Practice E-15 Procedure | Practice E-15 Procedure | | |
| 2:00 | | | | | |
| 2:30 | | | | | |
| 3:00 | | | | | |
| 3:30 | Open Discussion | 505 Warm-up/Carbon Canister | MTBE Series/1991 MTBE | Remove vehicle set-ups | |
| | Tuesday E-15 Practice | Mr. James Callison | Results/KS Cars - Omit Min. | | |
| 4:00 | Knock Sensor Exercise | Open Discussion | "B" | | |
| | | Collect Data Sheets | Mr. Tim Wusz (Unocal) | | |
| 4:30 | Adjourn | Adjourn | Open Discussion/Collect Data | Adjourn | |
| | | | Sheets/Adjourn | | |

Craig Carlson
May 18, 1992

# APPENDIX C

**E-15-92**

Attachment 2

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

**(CRC Designation E-15-92)**

**MAY 1992**

## I. OBJECTIVE

This procedure establishes the octane number requirements of light-duty vehicles, under defined test conditions. Testing will be conducted with a series of reference fuels using full-throttle and part throttle accelerations and transient-throttle maneuvers.

## II. OVERVIEW OF TEST PROCEDURE

### A. Test Procedure

The first step in octane rating is to determine the transmission characteristics of the vehicle. This information tells the driver what engine speed and manifold vacuum is used to obtain the engine conditions needed to measure octane requirement. The transmission characteristic information is not part of the octane requirement data, but is obtained as an aid to the driver.

The maximum octane requirement of the vehicle is the highest octane number fuel in a fuel series which causes borderline knock in at least one engine condition. When the highest knocking fuel causes above-borderline knock, the maximum octane requirement is intermediate between that fuel and the next highest non-knocking fuel. A maximum octane requirement is determined on each of the fuel series. The part-throttle requirement on the FBRU fuel series is investigated and reported in the octane number interval up to four numbers less than the wide-open-throttle requirement.

### B. Data Forms

Data Form ONRS-MY* consists of four sides: A, B, C, D. Side A includes company information, vehicle data, weather data, knock data on tank fuel, and the octane number requirement summary. Completion of the octane number requirement summary is discussed in Section IX. Side B has a table for transmission characteristic information. This information is located for convenient reference during the octane rating procedure. Side B also has a check list of items to be used during vehicle preparation. Side C is used during the octane rating procedure to record the data from all accelerations, whether they give knock or not.

*MY = current model year

Side D continues the data from side C. It also contains footnote references for the entire form and space for any comments the rater wishes to make. If the rating procedure requires more space for data than is provided in sides C and D, additional C and D sides should be used.

A completed Owner's Questionnaire Form ONRS-MY, Side E should be obtained if the vehicle has a regular driver and the engine spark timing has not been adjusted for testing.

## III. TEST PREPARATION

The vehicle must be prepared to operate as the manufacturer intended, but with an auxiliary fuel system. Care should be exercised when preparing the vehicle for testing to ensure that the test reflects normal operating conditions.

### A. Vehicle Inspection

Vehicles should be inspected to ensure that engine operation is correct. A list of required items to check is included on ONRS-MY, Side B. This list is a guide only. Individual laboratories may choose to check additional vehicle characteristics.

### B. Test Equipment Installation

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

One calibrated vacuum gauge, 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 or superchargers, a compound vacuum/pressure gauge should be used; the pressure side of the gauge should be capable of indicating pressures up to 15 psig (103 kPa).

An auxiliary fuel system shall be provided to supply test fuels to the engine. Fuel pressure and fuel line size should meet manufacturer's specifications. Auxiliary fuel systems are fuel-system-type-specified and instructions are given in Appendix A.

The vehicle's evaporative emission canister should be disconnected and plugged at the outlet to the engine. A slave canister that is clear of residual vapor should be installed on the vehicle, and normal engine connections should be made. The original vehicle canister must be left in place, and the line from the tank must remain connected to it. Connections need not be made between the slave canister and the auxiliary fuel system.

### C. Data Recording

Record vehicle identification number and emission control type, Federal, Altitude, California, or Fifty-State. Fill in headings on Data Form ONRS-MY, Sides A and C. Ford emission calibration numbers are to be recorded.

Record basic spark timing before adjustment to manufacturer's specifications.

For vehicles with owner questionnaire completed for the ONRS, a sample of the tank gasoline shall be withdrawn for determination of Research and Motor octane number ratings. If insufficient fuel is available, omit this step and tank fuel observations.

## IV. TEST CONDITIONS

All octane number requirements will be determined under level road acceleration conditions. Noise in the passenger compartment should be similar to noise encountered during normal road conditions. Windows should be closed or sealed, and the radio should be off. If testing is to be conducted on a chassis dynamometer, coastdown and/or acceleration data should be used to determine dynamometer load (level road conditions).

Tests will be conducted in moderately dry conditions, preferably at ambient temperatures between 60°F (16°C) and 90°F (32°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. Record temperature, pressure, and humidity on the data form.

A procedure to stabilize vehicle operating temperatures and to acclimate the engine control system to the test fuel is described below. The warm-up and stabilization cycle should be a replicate of the first 505 seconds of the Federal Test Procedure (FTP) cycle. It should be initiated with the ignition key in the off position for five seconds. The ignition key should be returned to the off position for five seconds at the completion of the warm-up and stabilization cycle. Vehicles should be driven through the warm-up and stabilization cycle three times in order to achieve a ten-mile warm-up. The initial vehicle warm-up will be conducted with tank fuel if an owner's questionnaire is present. Otherwise, the initial warm-up should be conducted with a non-knocking hydrocarbon-only fuel. Following the tank fuel rating, the vehicle should be re-stabilized with two 505-second cycles using a non-knocking hydrocarbon-only fuel. Because the stoichiometry of the FBRUM fuel is significantly different from the other test fuel series, the warm-up and stabilization procedure should also be conducted between the PR and FBRUM fuels series. A non-knocking FBRUM fuel should be utilized for warm-up and stabilization. A 15 volume percent MTBE and non-knocking hydrocarbon blend can be substituted for the FBRUM fuel for warm-up, if fuels are short.

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

Air-conditioned vehicles will be tested with air conditioner turned ON in the normal mode, set at a comfortable temperature, with low fan.

## V. FUELS

Octane number requirements are determined using the vehicle's tank fuel, and four reference fuel series.

Vehicle tank fuel is tested to obtain a preliminary indication of the vehicle octane number requirement. It will also be octane-rated and data included on Data Form ONRS-MY, Side A, if an Owner's Questionnaire Form ONRS-MY, Side E has been completed.

Octane number requirements are also determined using four reference fuel series. Two are designed using typical refinery components and are blended from three base blends in one or two Research octane numbers (RON) increments.

Full-Boiling Range Unleaded (FBRU) fuels are blended to a typical octane sensitivity. Octane sensitivity is defined as the difference between the fuel's RON and Motor octane number (MON) ratings.

Full-Boiling Range Sensitive Unleaded (FBRSU) fuels are blended to a target sensitivity two octane numbers higher than the FBRU fuel.

Full-Boiling Range Unleaded MTBE (FBRUM) fuels are blended by adding 15 volume percent MTBE to the FBRU fuels.

Primary Reference (PR) fuels comprise the fourth reference fuel series and are a volume blend of two components, isooctane and normal heptane. PR fuels are blended in one or two octane number increments, and by definition have zero sensitivity. PR fuels are defined in ASTM D2699 and D2700 test procedures.

Fuels are tested in a specific order. Tank fuel is tested first. The reference fuels are then tested in the following order: FBRU, FBRSU, PR, FBRUM.

## VI. DETERMINATION OF AUTOMATIC TRANSMISSION CHARACTERISTICS

Automatic transmission vehicles should be tested with the gear selector in the top forward gear, normally found to the right or below neutral; top gear should not be locked out unless noted otherwise by the manufacturer. Transmissions equipped with automatic overdrive should be operated in overdrive unless noted otherwise by the manufacturer. Transmissions equipped with power/normal selection should be operated in the normal position.

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

Determine the minimum road speed for converter clutch applications in each gear by gentle acceleration from the minimum speed to obtain the gear until the converter clutch engages. Record manifold vacuum, engine rpm, and vehicle speed on Data Form ONRS-MY, Side B.

Obtain the transmission downshift characteristics to define the detent curve for the gear/converter clutch combination.

1) Starting from a constant speed of 25 mph (40 kph), open the throttle until downshift occurs. Observe manifold vacuum and engine rpm.

2) Repeat Step 1 at higher vacuums until a vacuum is found which does not cause downshift. Record vacuum and rpm.

3) Repeat Steps 1 and 2, starting, in succession, from 35, 45, 55, and 65 mph (56, 72, 88, and 105 kph), and in all available gear/converter clutch combinations available at each speed.

## VII. DRIVING PROCEDURES

Octane number requirements will be evaluated under both full-throttle and part-throttle accelerations. The vehicles will be evaluated to determine the transmission gear position and throttle position of maximum knock intensity, which is the critical operating condition.

**A. Manual Transmissions**

Accelerations will not be made in all transmission gears. Accelerations and critical vacuum/pressure determinations will be investigated per the following gear selection table:

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

Accelerations will start from the lowest speed from which the vehicle will accelerate smoothly or 25 mph (40 kph), whichever is higher.

Full-throttle accelerations are made with the throttle fully depressed.

Part-throttle accelerations are made with the throttle depressed at least one inch Hg (3.3 kPa) higher than the full-throttle manifold vacuum/pressure. Part-throttle accelerations start at the minimum obtainable speed in the test gear to 70 mph (113 kph), or until the vehicle ceases to accelerate reasonably. Part-throttle accelerations to measure vehicle octane number requirements are performed at critical vacuum/pressures.

To obtain critical part-throttle vacuum/pressure, operate at constant speed road load at 25, 35, 45, 55, and 65 mph (40, 56, 72, 88, and 105 kph) incremental speeds. At each speed, move the throttle from road load vacuum to the positions described below:

For naturally-aspirated vehicles, one inch Hg (3.3 kPa) above full-throttle vacuum;

For turbocharged vehicles, one inch Hg (0.5 psig or 3.3 kPa) below maximum boost.

The throttle movement from road load to the prescribed position should take place in approximately three seconds. This procedure is called fanning. If knocking occurs within any of the vacuum/pressure ranges, establish the manifold vacuum/pressure which gives maximum knock intensity. This is the critical vacuum/pressure to be used for all subsequent constant-vacuum/pressure part-throttle accelerations.

The critical part-throttle vacuum/pressure may be different for other fuel series and must be reinvestigated for each series.

**Use of vehicle brakes must be avoided.**

**B. Automatic Transmissions**

Accelerations must be made with the selector in the top forward gear, normally found to the right or below neutral; top gear should not be locked out. Transmissions equipped with electronic overdrive should be operated in overdrive. Transmissions equipped with power/normal selections should be operated in the normal position.

Accelerations will not be made in all transmissions gears. Accelerations and critical vacuum/pressure determinations will be done as shown in the following gear table. If a particular gear/lock-up combination cannot be obtained, it will not be tested.

| Type | Gears to be Tested |
|---|---|
| 4-speed with torque converter lock-up | 4th gear, converter clutch engaged<br>4th gear, converter clutch disengaged<br>3rd gear, converter clutch engaged<br>3rd gear, converter clutch disengaged<br>2nd gear, converter clutch disengaged |
| 4-speed without torque converter lock-up | 4th gear<br>3rd gear<br>2nd gear |
| 3-speed with torque converter lock-up | 3rd gear, converter clutch engaged<br>3rd gear, converter clutch disengaged<br>2nd gear, converter clutch disengaged |
| 3-speed without torque converter lock-up | 3rd gear<br>2nd gear |

Accelerations in each of the transmission gears or gear/converter clutch combinations specified above will start from the minimum obtainable road speed and continue until maximum test speed is obtained or, in the case of part-throttle, the vehicle ceases to accelerate reasonably. Minimum obtainable road speeds were established when automatic transmission characteristics were investigated in Section VI. Maximum test speed is 70 mph or a road speed corresponding to 750 rpm above maximum torque, whichever is lower. If the transmissions downshifts, abort and start the acceleration again.

Full-throttle accelerations are made with the throttle depressed in the widest throttle position that does not cause the transmission to downshift or the torque converter clutch to disengage. These accelerations are made following the speed-vacuum/pressure curves established in Section VI.

Part-throttle accelerations are made with the throttle depressed at least one inch Hg (3.3 kPa) higher than the full-throttle manifold vacuum/pressure. Part-throttle accelerations start at the minimum obtainable speed in the test gear to 70 mph (113 kph), or until the vehicle ceases to accelerate reasonably. Part-throttle accelerations to measure vehicle octane number requirements are performed at critical vacuum/pressures.

The critical part-throttle vacuum/pressure investigations will be conducted in the two highest transmission gear positions with the available combinations of converter clutch locked or unlocked. Investigation of critical condition should start with the highest transmission gear with converter clutch engaged. Begin from road load speed of 25 mph (40 kph) or minimum obtainable road speed for the gear/converter clutch combination. Continue the investigation at speeds of 35, 45, 55, and 65 mph (56, 72, 88, and 105 kph), if obtainable.

At each speed, move the throttle from the road-load vacuum/pressure to the detent or torque converter declutch position described below. This throttle maneuver should be accomplished in about three seconds, and is called fanning.

1. For naturally aspirated vehicles, one inch Hg (3.3 kPa) above:

   a. detent vacuum for automatic transmissions without converter clutches;

   b. the minimum vacuum at which the converter clutch disengages for so-equipped automatic transmissions.

2. For turbocharged vehicles, one inch Hg or 0.5 psig (3.3 kPa) below:

   a. maximum boost at detent for automatic transmissions without converter clutches;

   b. maximum boost or 0.5 psig (3.3 kPa) above the minimum vacuum at which the converter clutch disengages for so-equipped automatic transmissions.

If knocking occurs within any of the vacuum/pressure ranges, establish the manifold vacuum/pressure which gives maximum knock intensity. This is the critical vacuum/pressure to be used for all subsequent constant-vacuum/pressure part-throttle accelerations.

The critical part-throttle vacuum/pressure may be different for other fuel series and must be investigated for each series.

If knock is encountered during the fanning procedure but not during the constant-vacuum/pressure part-throttle accelerations, it should be recorded as tip-in.

**Use of vehicle brakes must be avoided**

## VIII. TEST PROCEDURE

### A. Fuel Changeover

To eliminate contamination of the new fuel with residual amounts of the previous fuel, fuel-injected systems should be flushed once with the new fuel and carbureted systems should be flushed twice. Fuel-handling procedures for vehicles equipped with fuel injection systems are explained in Appendix A.

Make one full throttle acceleration after the fuel change, unless the fuel is being changed to an oxygenated fuel, in which case two 505-second Federal Test Procedure cycles should be performed.

### B. Determination of Knock Intensity

Spark knock is the noise associated with the 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. This includes knock occurring when going from road load to other operating conditions (e.g., tip-in, etc.)

---

*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.

Borderline knock is spark knock of lowest audible intensity of at least three pings, and over a range of engine speed of 50 rpm or more, all being repeatable during subsequent accelerations and being sensitive to fuel octane.

No knock means either no audible knock or knock less than borderline intensity.

Above-borderline knock means spark knock of greater audible intensity (louder) than borderline and sensitive to fuel octane quality. There is no restriction on number of pings.

Knock-in is the rpm at which knock is first encountered. Knock-out is the rpm at which knock is last encountered.

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) rated accelerations. Coastdown time between the end of one acceleration and the beginning of the next should be consistent and a minimum of twenty (20) seconds. As defined below, the first two duplicating accelerations are sufficient with "N" and "B" intensity.

**"A" knock intensity must not be maintained during an acceleration.** If "A" knock intensity occurs, back off the throttle from detent, maintaining "B" level knock by approaching the detent curve as knock fades. Do not duplicate this acceleration. Testing will continue with a higher octane number fuel in that series.

**Maximum Octane Number Requirement Determination**

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

## C. Tank Fuel

Knock on tank fuel is determined for those ONRS vehicles which have a completed owner's questionnaire. Investigate for full-throttle and part-throttle knock in each of the gears or gear/converter clutch combinations shown in the transmission characteristics table in Section VII A and B. Record knock intensity, engine speed, and manifold vacuum/pressure at each operating condition.

## D. FBRSU, PR, and FBRUM Fuel Series

The test procedures used for the FBRSU, PR, and FBRUM fuel series are the same. All three fuel series are tested after the FBRU series, with the FBRUM fuel series tested last. Knock is investigated in all fuel series in each of the gears or gear/converter clutch combinations shown in the transmission characteristics table in Section VII A and B.

Estimate which fuel will be just clear of borderline knock. For the FBRSU series, this estimate is based on data from the FBRU series, while for the PR series, it is based on data from the FBRSU and FBRU series. The steps in determining the octane requirement of the vehicle on these fuel series include several decision points and are illustrated on page 30 in a flow sheet.

## E. FBRU Series

Based on tank fuel information, estimate which fuel will be just clear of borderline knock. The flow sheet which gives the steps for octane rating a vehicle on FBRU series begins on page 32. Testing on the FBRU series is more extensive than testing on FBRSU, PR, or FBRUM series. If the vehicle is full-throttle limited, part-throttle conditions are investigated up to four octane numbers below the full-throttle requirement.

# IX. DATA SUMMARY

## A. Raw Data Entry

The purpose of the raw data record is to allow anyone familiar with the rating procedure to independently determine the actual test performed. The original data will be recorded on Form ONRS-MY, Sides C and D, which is the first and permanent record of the results of the rating. This means that data sheets must not be rewritten or typed. In case an error is made, draw a line through the error. Do not erase. All fuels tested must be recorded on Sides C and D whether or not knock is encountered.

## B. Vehicle and Test Condition Data

Vehicle and test condition data are recorded on Form ONRS-MY, Side A. Many of the data required are further explained in the footnotes on Side D. Care should be taken to record data in the units printed on the form or using the codes on the form and explained in the footnotes. Special care should be taken to record the VIN correctly, because this information is crucial to properly assigning the vehicle to the correct Survey vehicle code.

If knock is encountered on tank fuel in more than one throttle and/or gear position, the knocking condition to record is the condition of most intense knock. If maximum- and part-throttle knock are of equal intensity, record the part-throttle condition. If two or more gear/torque converter conditions knock with equal intensity, record the highest gear/torque converter condition. If no knock are encountered, no further data are recorded.

## C. Octane Number Requirement Summary

The octane number requirement summary block is on the bottom part of Form ONRS-MY, Side A. The data in this block are derived from the original data on Sides C and D. The summary block provides space for both maximum-throttle and part-throttle requirements for the maximum octane requirement for all vehicles. If both maximum-throttle and part-throttle requirements have been found, record both.

Use proper letter designations (see the footnotes on the data sheet) to designate: (1) requirements outside of the reference fuel limits; (2) FBRU part-throttle requirement more than four numbers below maximum; and (3) all other cases for which the octane number requirement has not been determined. Note that in the case of a converter-clutch-equipped vehicle, test gear numbers should indicate whether the converter clutch was locked or unlocked. This should be done for all gears. Note also that in the case of turbocharged or supercharged vehicles, a manifold pressure above atmospheric is indicated as a negative number in units of psig.

When deriving summary data from the raw data, the following guidelines shall be used.

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 number requirement in high gear is equal to the requirement in a lower gear, report the highest gear data. Locked condition is higher than unlocked.

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

## X. GLOSSARY TERMS

| | | |
|---|---|---|
| A | = | Above-Borderline Knock (see Section VIII B) |
| B | = | Borderline Knock (see Section VIII B) |
| BTDC | = | Before Top Dead Center |
| Critical Manifold Vacuum/Pressure | = | the manifold vacuum/pressure which gives maximum knock intensity during a P/T acceleration (see Section VII) |
| Detent | = | Throttle position at any speed which is at the point of incipient downshift. (see Section VI) |
| EGR Valve | = | Exhaust Gas Recirculation Valve |
| FBRU | = | Full-Boiling Range Unleaded Average Sensitivity Fuel (see Section V) |
| FBRSU | = | Full-Boiling Range Unleaded High Sensitivity Fuel (see Section V) |
| FBRUM | = | Full-Boiling Range Unleaded Average Sensitivity (FBRU) Fuel with 15 volume percent MTBE splash-blended into it (see Section V). |
| F/T | = | Full-Throttle (see Section VII A) |
| Gr/lb | = | Grains of water per pound of air |
| GVW | = | Gross Vehicle Weight |
| Hg | = | Mercury |
| kg | = | kilogram |
| Km | = | Kilometers |
| Knock-In | = | the rpm at which knock is first encountered (see Section VIII B) |
| Knock-Out | = | the rpm at which knock is last encountered (see Section VIII B) |
| kPa | = | kilo Paschal |
| kph | = | kilometers per hour |

lb = pound

MAX = Maximum

Maximum Requirement/Maximum Octane Number Requirement = the highest octane number fuel in a fuel series which causes borderline knock in at least one engine condition (see Section II A)

MON = Motor Octane Number

mph = miles per hour

N = No Knock (see Section VIII B)

ON = Octane Number

PCV Valve = Positive Crankcase Ventilation Valve

PFI = Port Fuel Injection

PR = Primary Reference Fuel (see Section V)

psig = pounds per square inch gauge

P/T = Part-Throttle (see Section VII A)

RON = Research Octane Number

RPM = Revolutions per minute

TBI = Throttle-Body Fuel Injection

TC = Torque Converter

TDC = Top Dead Center

# DEFINITIONS AND DESCRIPTIONS FOR OCTANE TEST PROCEDURE GUIDE

A = Above Borderline Knock

B = Borderline Knock

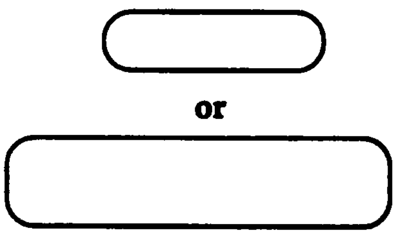
N = No Knock

ON = Octane Number

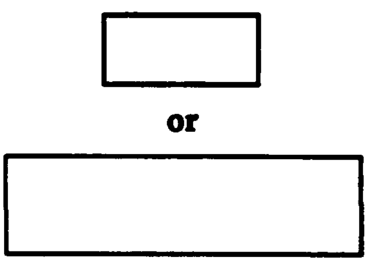
F/T = Full Throttle

P/T = Part Throttle

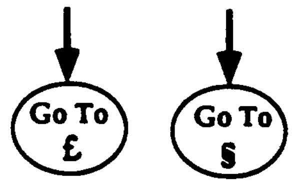
Gear/TC = Gear/Torque Converter



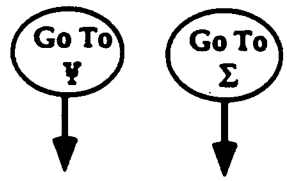

= Decision Point




= Operation



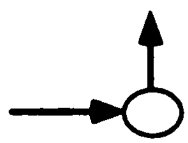

= Exit To New Page



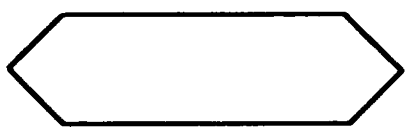

= Entry Point On New Page

= Pathway

= Go To Another Point

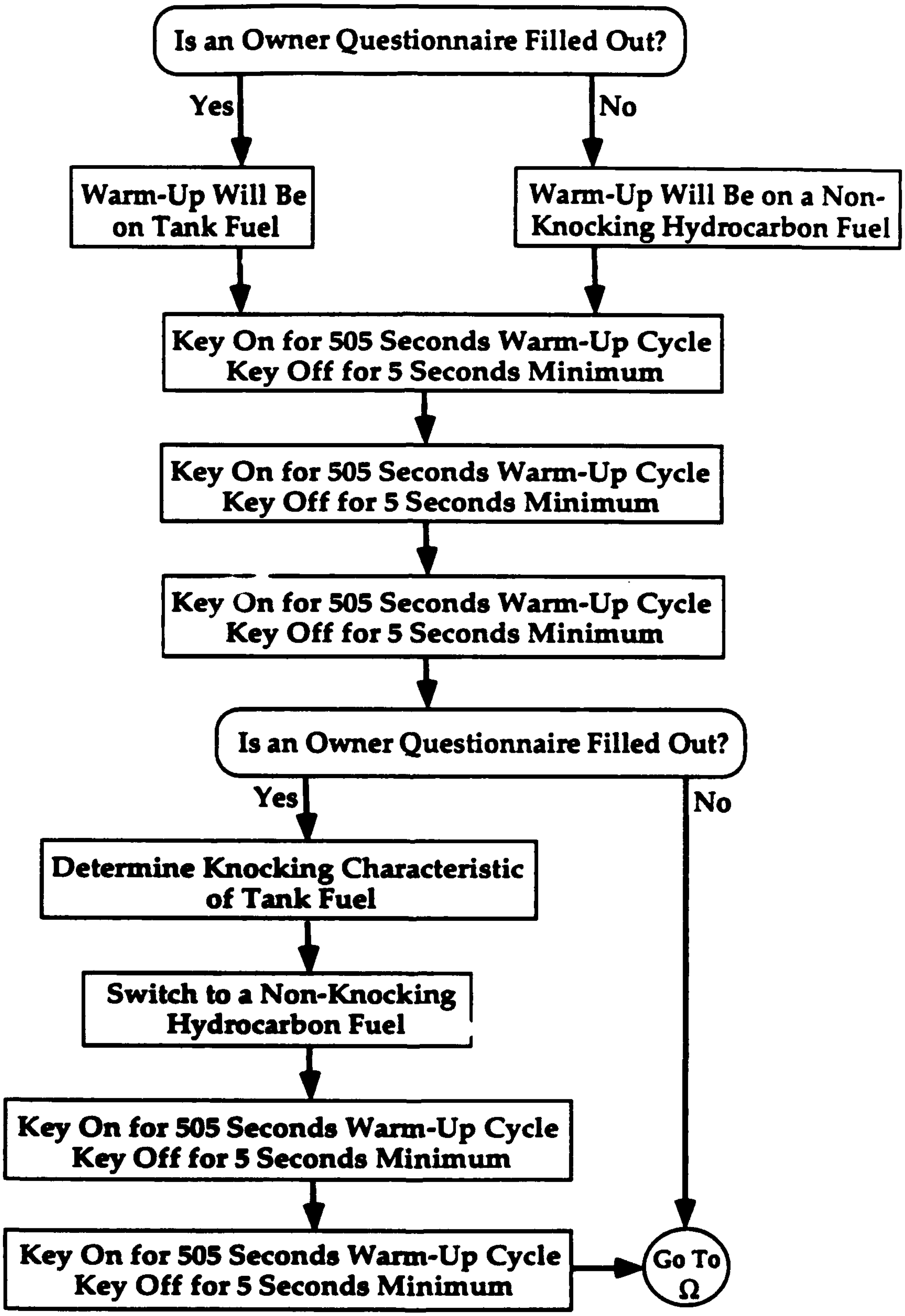


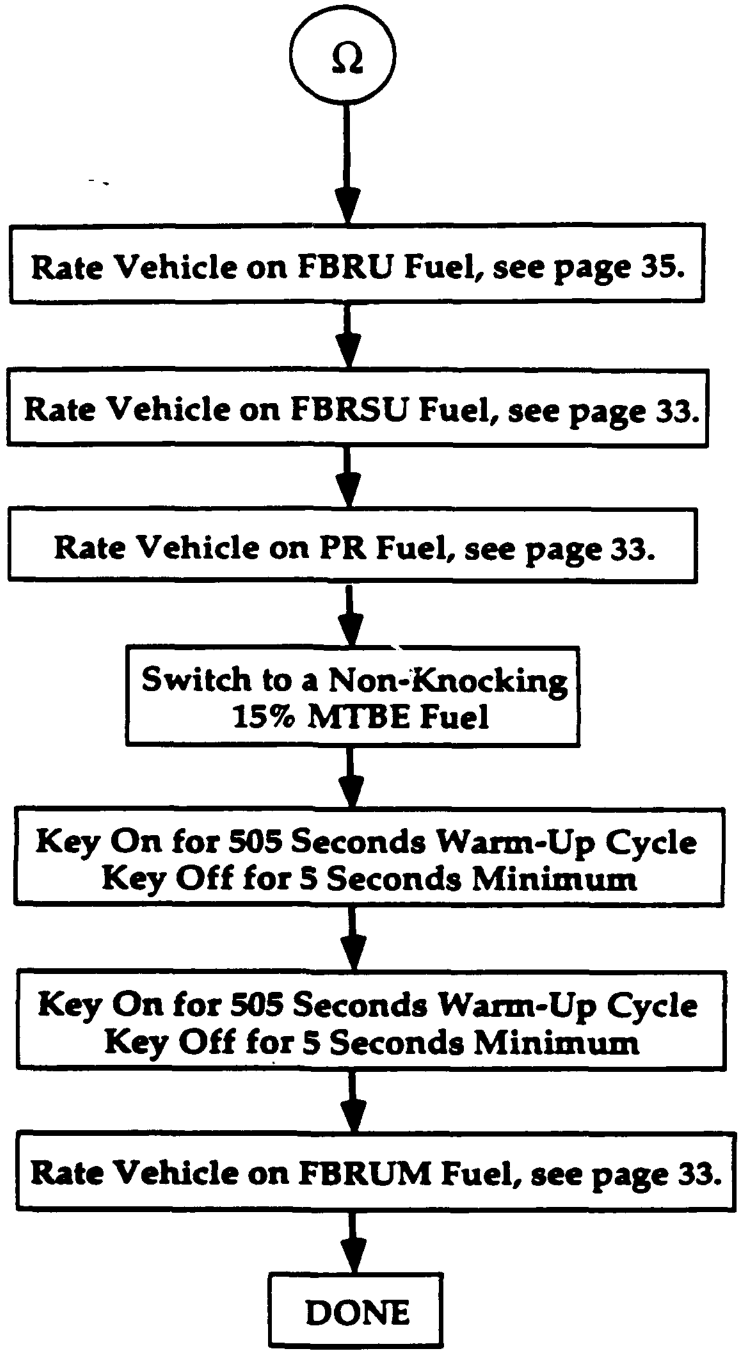
= Entry Point



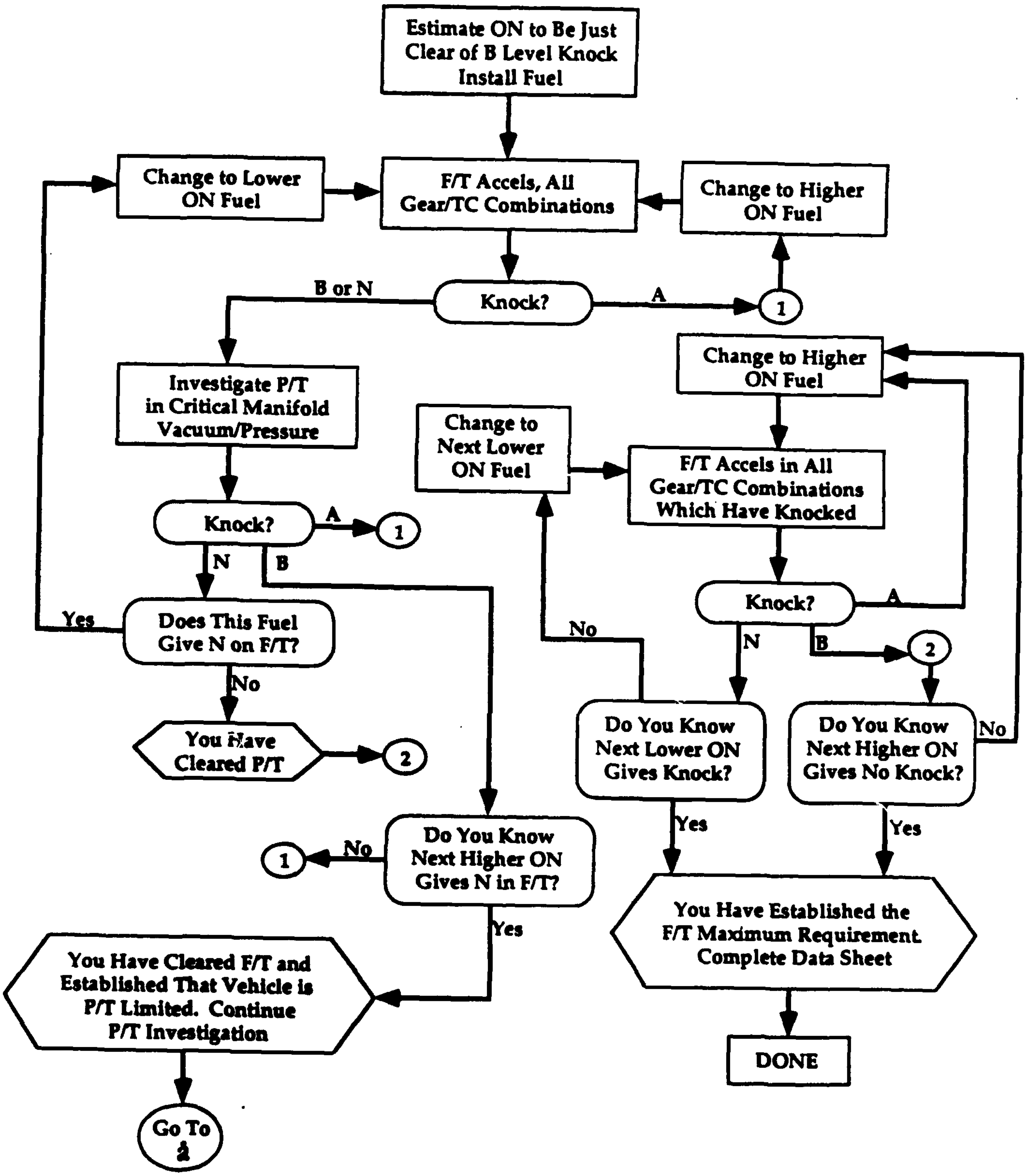
= Completed Segment

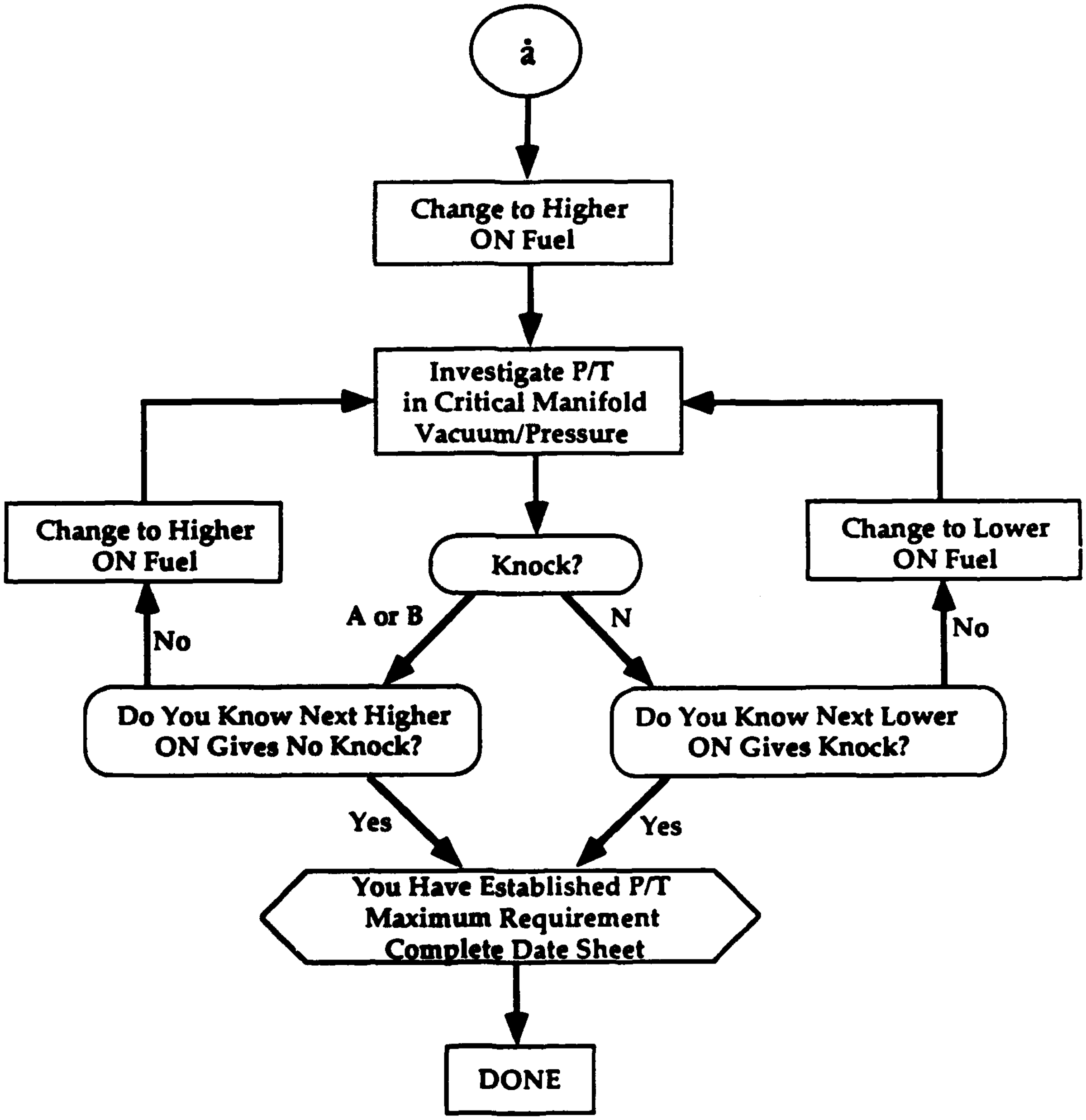
# TEST PROCEDURE OVERVIEW



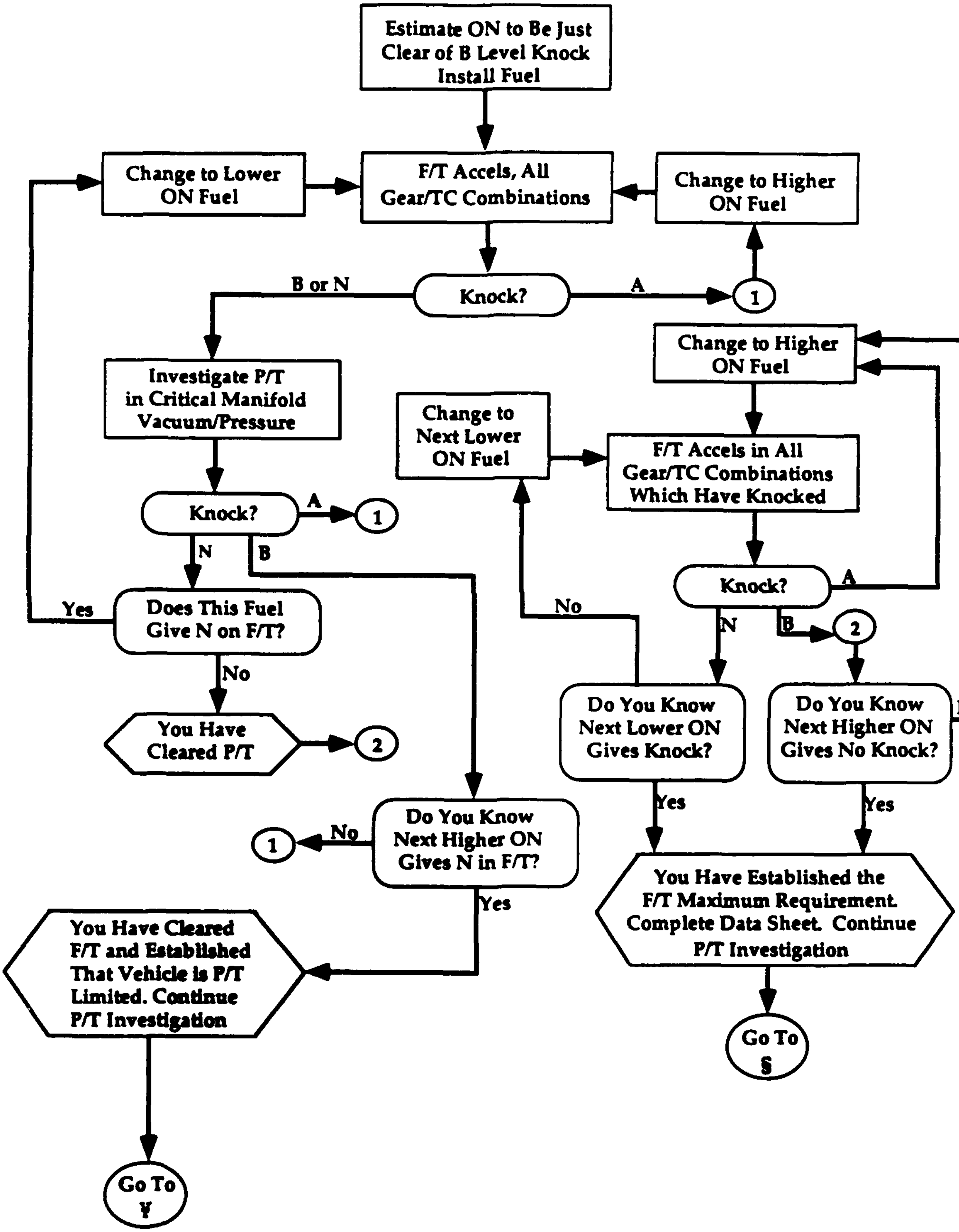

Ω
Rate Vehicle on FBRU Fuel, see page 35.
Rate Vehicle on FBRSU Fuel, see page 33.
Rate Vehicle on PR Fuel, see page 33.
Switch to a Non-Knocking 15% MTBE Fuel
Key On for 505 Seconds Warm-Up Cycle Key Off for 5 Seconds Minimum
Key On for 505 Seconds Warm-Up Cycle Key Off for 5 Seconds Minimum
Rate Vehicle on FBRUM Fuel, see page 33.
DONE

# OCTANE TEST PROCEDURE GUIDE FOR FBRSU, PR, AND FBRUM FUEL SERIES

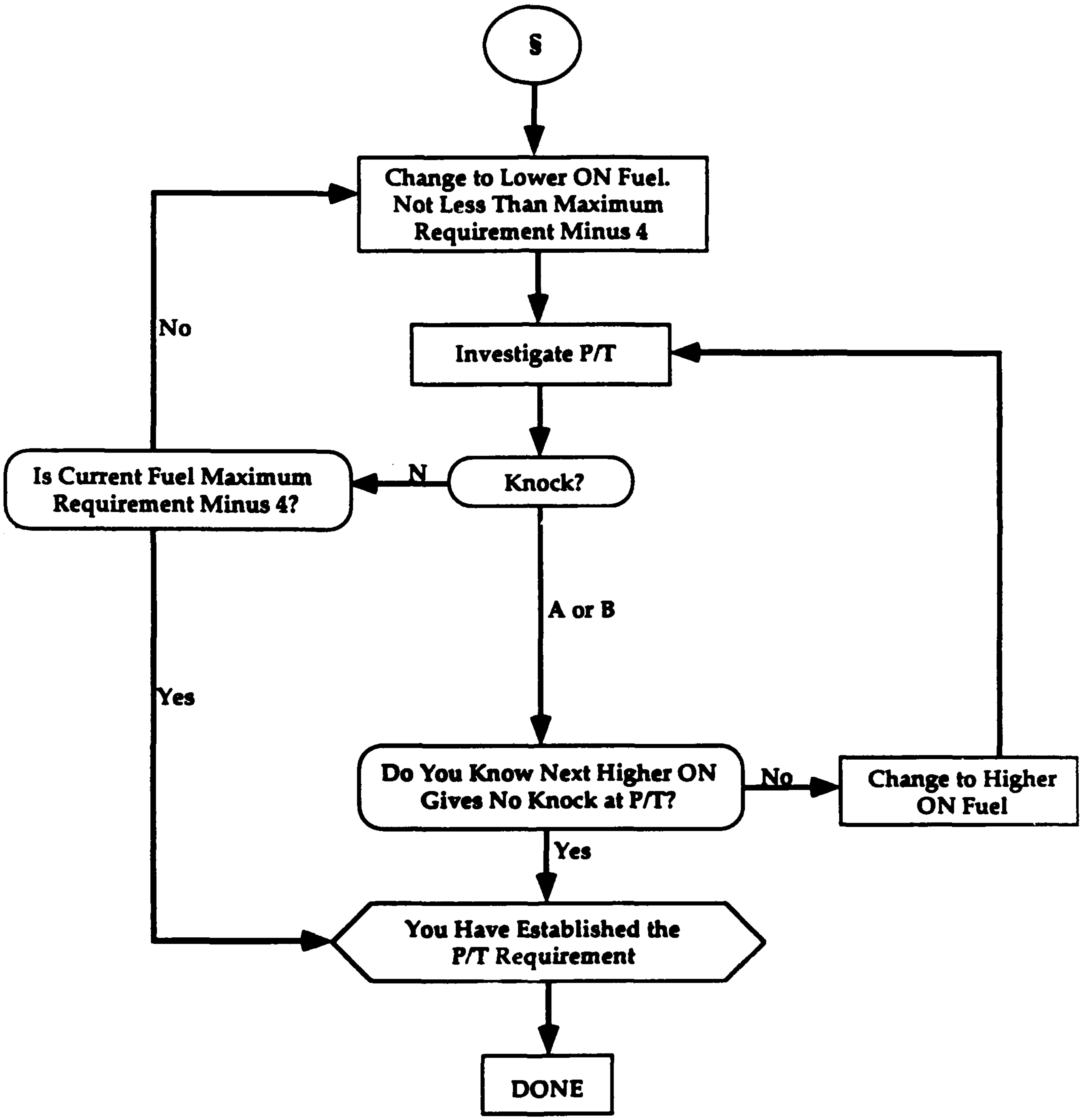



a
Change to Higher ON Fuel
Investigate P/T in Critical Manifold Vacuum/Pressure
Change to Higher ON Fuel
Knock?
Change to Lower ON Fuel
A or B
N
No
No
Do You Know Next Higher ON Gives No Knock?
Do You Know Next Lower ON Gives Knock?
Yes
Yes
You Have Established P/T Maximum Requirement Complete Date Sheet
DONE

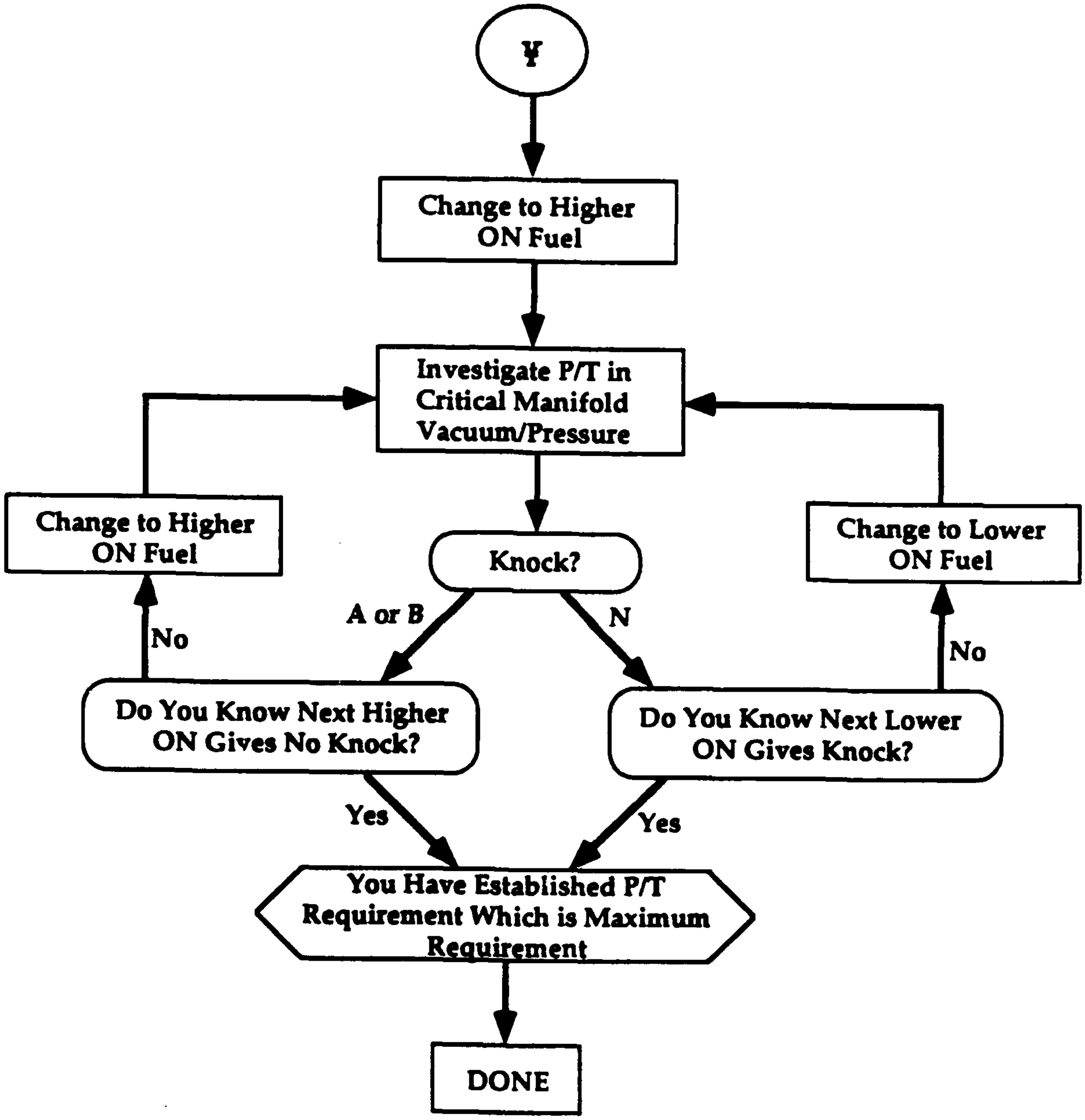
# OCTANE TEST PROCEDURE GUIDE FOR FBRU FUEL SERIES



# P/T Investigation For Vehicles With Maximum Requirement at F/T



# Investigation of Maximum Requirement at P/T for P/T Limited Vehicles



ONRS-92
Side A

Sheet___of___Sheet

# 1992 CRC OCTANE NUMBER REQUIREMENT SURVEY - 1992 MODEL VEHICLES

Company:______________ Date:__________ Test Location (R/C):__________ (1)*

Primary Contact:____________________ Phone: (    ) __________

Driver:______________ Observer:____________________

**TO BE FILLED IN BY CRC:** Observ. No.:_____-_____ Veh. Code:__________ VIN Digit:_____ Owner:______

**VEHICLE DATA**

Vehicle Make:______________ Model:______________

Engine Type:_________ (2)* V.I.N.: |__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|__|

Engine Calibration (Ford):______________ License No.:______________

Knock Sensor (Y/N):_______ Emission Certification (F/C/A/B/E):_________ (3) Induction (T/S): ________ (4)

Carburetion (P/T/1..4):__ (5) Displacement (Liters): ______.______ Compression Ratio:_____._____

Transmission (A/M):_______ (6) No. of Speeds:________ (7) Converter Clutch (Y/N):__________

Spark Advance (Degrees BTDC) (8): As Received:__________ As Tested:__________

Air Conditioning (Y/N):_______ Odometer (Miles):______________

**WEATHER** Ambient Temperature (°F):________ Barometer ("Hg):_____._____ Humidity (Gr/Lb):__________

**VEHICLE SOURCE** Owner-Operated:_____ Rental:_____ Other:______________

**TANK FUEL DATA** Customer Knock (Y/N/O):_________ (9) Research Octane No.:______.___ Motor Octane No. ______.___

Knock Intensity (N/B/A):________ (10) Throttle (M/P):________ (11) Test Gear No.:__________ (12)

RPM @ Max. Knock Intensity:_________ Man. Vac. ("Hg/psig):_____._____ (13)

## MAXIMUM OCTANE NUMBER REQUIREMENT SUMMARY

| Ref Test Fuel | FULL-THROTTLE REQUIREMENT | | | | PART-THROTTLE REQUIREMENT | | | |
|---|---|---|---|---|---|---|---|---|
| | Research Oct. No. (15) | Test Gear (12) | RPM @ Max. Knock | Manifold Vacuum ("Hg/psig) (13) | Research Oct. No. (15) | Test Gear (12) | RPM @ Max Knock | Manifold Vacuum ("Hg/psig) (13) |
| FBRSU | ____.___ | ____ | ____ | ____.___ | ____.___ | ____ | ____ | ____.___ |
| FBRU | ____.___ | ____ | ____ | ____.___ | ____.___ | ____ | ____ | ____.___ |
| PR | ____.___ | ____ | ____ | ____.___ | ____.___ | ____ | ____ | ____.___ |
| FBRUM | ____.___ | ____ | ____ | ____.___ | ____.___ | ____ | ____ | ____.___ |

* See Side D for explanatory legend.

Side B

TRANSMISSION DOWNSHIFT CHARACTERISTICS

| 4th Locked Overdrive | | | 4th Gear | | | 3rd Locked | | |
|---|---|---|---|---|---|---|---|---|
| mph | Man. Vac./psig | RPM | mph | Man. Vac./psig | RPM | mph | Man. Vac./psig | RPM |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
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| 3rd Gear | | | 2nd Locked | | | 2nd Gear | | |
|---|---|---|---|---|---|---|---|---|
| mph | Man. Vac./psig | RPM | mph | Man. Vac./psig | RPM | mph | Man. Vac./psig | RPM |
| | | | | | | | | |
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**VEHICLE INSPECTION LIST**

____ Vacuum Lines - Good Condition and Appropriately Connected

____ Air Pump Hoses - Good Condition and Appropriately Connected

____ PCV Valve Functioning

____ EGR Valve - Functioning

____ Heated Inlet Air - Functioning

____ Anti-dieseling solenoid - Functioning and adjusted properly

____ Tire pressure

____ Crankcase Oil Level

____ Coolant Level

____ Automatic Transmission Fluid Level

____ Charge Indicator Light or Fluid Level of Battery

____ Carbureted Engines - Plug Fuel Return Line if present

____ Disconnect Fuel Tank Vent Line at Vacuum Cannister

____ Check Fault Codes

ONRS-92
Side C



Sheet____of____Sheets

1992 CRC OCTANE NUMBER REQUIREMENT SURVEY - 1992 MODEL VEHICLES
CONTINUATION SHEET

Company:______________________________ Date:______________________________

Vehicle Make:______________________________ Model:______________________________

V.I.N.:______________________________ License No.:______________________________

TO BE FILLED IN BY CRC: Observation No.:____-____

| Reference Fuel | | Test Gear No. (12) | Throttle Position (16) | Man. Vac. Hg/psig (13) | Max. Knock Intensity (10) | | | (10) | Speed Range, RPM | | RPM of Max. of Intensity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Series | Res. O.N. | | | | Acceleration 1 | 2 | 3 | Final Rating | Knock In | Knock Out | |
| | | | | | | | | | | | |
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Side D

| Reference Fuel | | Test Gear No. (12) | Throttle Position (16) | Man. Vac. Hg/psig (13) | Max. Knock Intensity (10) | | | (10) | Speed Range, RPM | | RPM of Max. of Intensity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Series | Res. O.N. | | | | Acceleration 1 | 2 | 3 | Final Rating | Knock In | Knock Out | |
| | | | | | | | | | | | |
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LEGEND

(1) R = Road; C = Chassis Dynamometer
(2) e.g. V8, L4, R for Rotary
(3) F = Federal; C = California;
A = Altitude; B = "C" and "A"
E = Everything
(4) T = Turbocharged; S = Supercharged
(5) Number of Carb. Venturis or T for throttle body injection or P for port injection
(6) A = Automatic; M = Manual
(7) Record number of transmission speeds
(8) + = BTDC; - = ATDC
(9) Y = Yes; N = No; O = Objectionable
(10) N = None; B = Borderline; A = Above Borderline
(11) M = Maximum-Throttle;
P = Part-Throttle higher than Maximum-Throttle Requirement
(12) If vehicle is equipped with converter clutch, in addition to gear number, indicate U for unlocked and L for locked (e.g., 3U)
(13) If boost pressure greater than atmospheric, use Manifold Pressure (psig) with minus sign (-); when fanning, write in "FAN"
(14) Applies only to knock-sensor vehicles.
(15) If ONR not bounded by test fuels,
L = Less than lowest available fuel;
H = Higher than highest available fuel.
If part-throttle requirement is greater than four numbers below maximum-throttle requirement, enter F.
If above does not apply and ONR is not determined, enter U.
(16) Record M for Maximum-Throttle, P for Part-Throttle, or FAN if fanning

COMMENTS

**APPENDIX A**

**to the**

**CRC E-15-92 TECHNIQUE**

**PROCEDURE FOR SETTING UP VEHICLES**

**WITH FUEL INJECTION**

# APPENDIX A

## PROCEDURE FOR SETTING UP VEHICLES AND HANDLING REFERENCE FUELS: VEHICLES EQUIPPED WITH FUEL INJECTION

1. To run octane requirements on fuel-injected vehicles, it is necessary to install an external fuel supply line with auxiliary electric fuel pump from the reference fuel can to the vehicle fuel system and an external return line back to the reference fuel can.

2. There are two types of fuel injection systems: throttle-body injection, and multi-port injection. As a general description, the systems will contain the following parts:

   Fuel Tank
   High- or Low-Pressure In-Tank Fuel Pump
   Fuel Supply Line(s)
   In-Line Filter(s)
   High-Pressure Chassis-Mounted Pump (not required for all vehicles)
   Fuel Rail (to supply multiple injectors on port fuel injection)
   Fuel-Pressure Regulator (integral on throttle-body, on fuel rail with multi-port injection; controls pressure at the injectors).

   Depending upon the vehicle's specific fuel system and/or tester's preference, installation of the required auxiliary equipment can be accomplished in a variety of ways.

3. The auxiliary fuel supply line may be installed anywhere between the fuel tank and the inlet at the throttle-body or fuel rail. The auxiliary fuel return line may be installed anywhere between the fuel-pressure regulator outlet and the tank.

4. After connections have been broken, the fuel lines on the fuel tank side should be capped and the vehicle's pump(s) disconnected or disarmed. Alternately, an additional fuel line can be looped between the supply and return lines and the vehicle pump(s) allowed to circulate fuel directly back to the fuel tank. Caution should be exercised if this alternate technique is used. A high pressure will build up in the tank due to the large amount of vapors generated.

The auxiliary fuel supply system must be capable of supplying fuel at a pressure slightly higher than the maximum fuel pressure required (at wide-open-throttle on normally aspirated engines or at maximum manifold boost pressure on turbocharged or supercharged engines) by the particular vehicle being tested. This is to overcome any line losses and thus insure accurate results. This may be accomplished by using an adjustable high-pressure pump, or by using a low-pressure pump to supply fuel to the chassis-mounted high-pressure pump if the testing lab chooses to keep it in the system. A fuel filter may be required between the auxiliary pump and the reference fuel can to protect the pump. The fuel return line should be connected to a tee at the auxiliary pump inlet. The reference fuel can should be vented to outside the vehicle.

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.

5. When changing from one reference fuel can 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. With the engine shut off, disconnect the fuel return line from the auxiliary pump inlet and connect it to a slop can. Connect the fuel supply line to the new reference fuel can and run the engine long enough to purge the old reference fuel from the system. The time required will be dependent upon length of added fuel lines, but it will be approximately 30-60 seconds; approximately 1-2 quarts of fuel will be discarded to slop.[1]

   c. With the engine off, connect the fuel return line to the auxiliary pump inlet. The vehicle is then ready to be tested.

   d. When changing to the next reference fuel, it is necessary to repeat Steps a, b, and c.

---

(1) It is critical to circulate an adequate amount of fuel to the slop can to prevent reference fuel contamination.

**CAUTION**

Fuel supply lines remain pressurized long after the engine is shut off; be sure to relieve the pressure before disconnecting fuel lines.

Use fuel lines designed for high pressure. They should be rated for at least 250 psi working pressure and for 1000 psi burst pressure.

The engine and auxiliary fuel pumps should be shut off while changing from auxiliary to tank fuels.

Purging procedures should be followed strictly to preclude reference fuel contamination or discarding more fuel than is required.

Vehicle pump(s) may be disarmed by use of the inertia switch if so equipped. The voltage supplied to the inertia switch may then be used to power the auxiliary pump. When making these electrical connections, do not "splice" into the wire; instead, connect the wire lead to the connector.

Do not disarm the vehicle fuel pump by removing the fuse, since other accessories may be connected to the same circuit; instead, disconnect the fuel pump electrical lead.

Auxiliary fuel return lines should be of a size larger enough to prevent a build-up of back pressure which could prevent the proper operation of the pressure regulator.

Use of the "rolled edge" style hose clamps, such as those made by Chrysler, is recommended to prevent damage to fuel lines.

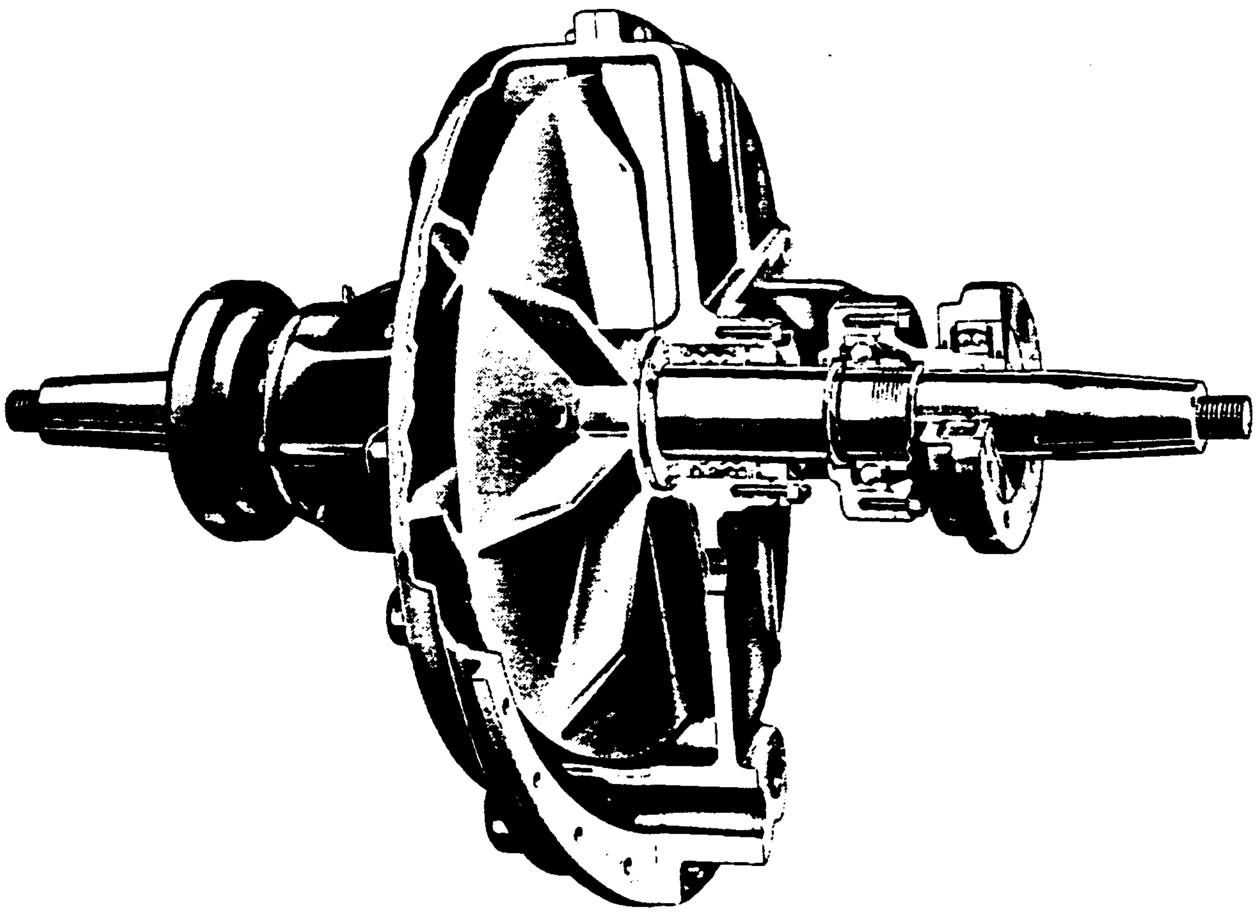
Note: Diagnostic scanners should not be used while knock testing.

# APPENDIX D

## CLAYTON DYNAMOMETER PRESENTATION

Clayton INDUSTRIES

# POWER ABSORPTION UNIT

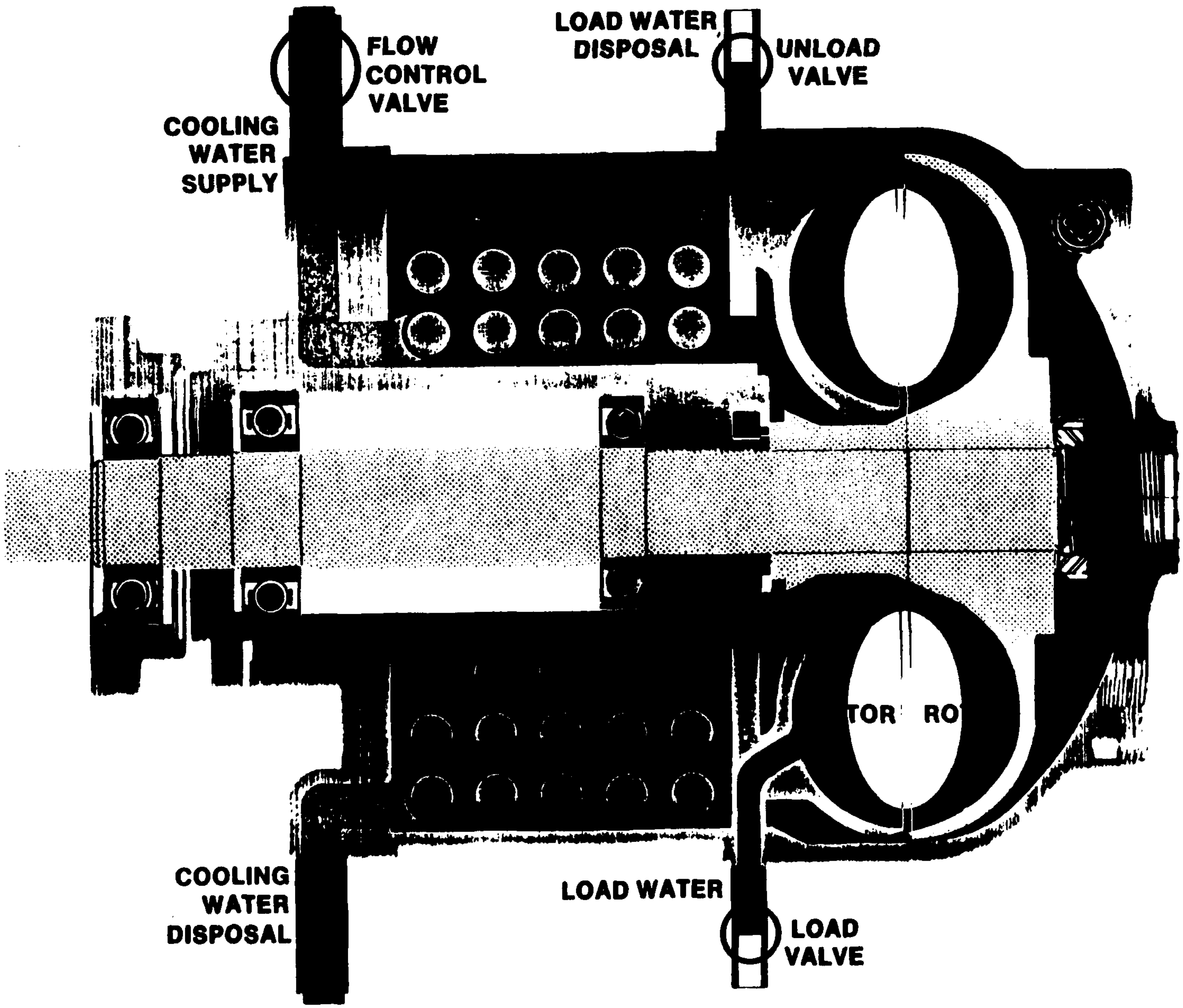


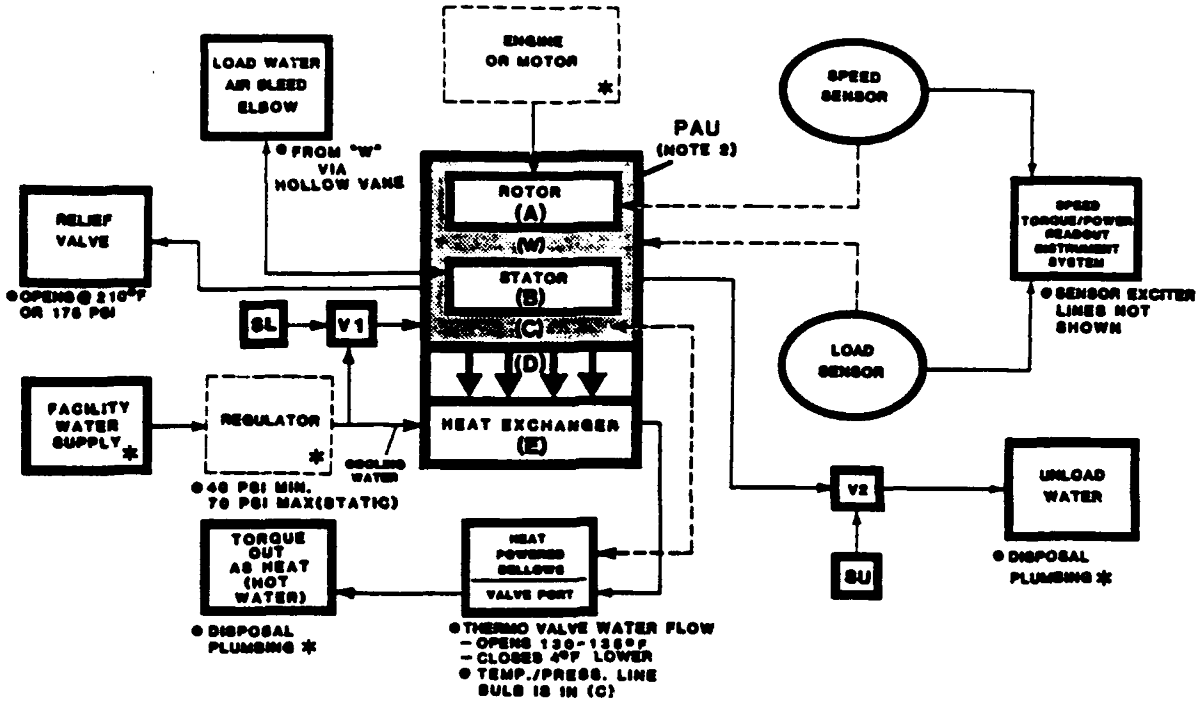
**The Clayton hydrokinetic PAU combines recirculation of load fluid through a heat exchanger with low rotative inertia to provide instant response to power changes and system cooling. Rapid circulation of load fluid within the rotor/stator heats the load fluid, a portion of which is pumped through the heat exchanger for load fluid temperature control.**

**For chassis dyno installation the rotor is connected to the roll, while for engine dyno usage, the rotor is connected through a drive shaft to the motor shaft.**

C-3094/500/11-84/Meritt

# CLAYTON POWER ABSORPTION UNIT
# EXCLUSIVE TURBO-CLOSED LOAD






## LEGEND

A: Rotor. Converts engine power to momentum of load water mass pumped against Stator.

B: Stator. Converts change of load water mass momentum into heat. Has hollow vane which opens "w" to bleed elbow.

C: Load Water Chamber. Rotor throws load water against stator vanes and shell.

D: Heat transfer from load water through walls of Heat Exchanger coils.

E: Cooling water passing inside the Heat Exchanger tubing coils picks up heat from coil walls.

SL: Load position of Toggle Switch on J-Box; Activates Load Solenoid V1.

SU: Unload position of Toggle Switch on J-Box; Activates Unload Solenoid V2.

V1: Load Solenoid (in J-Box)

V2: Unload Solenoid (in J-Box)

*: Furnished by User.

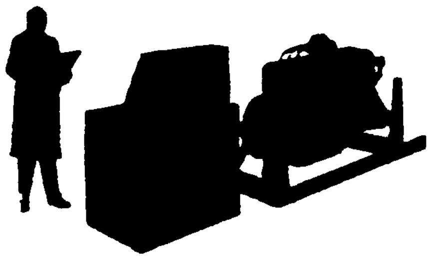
W: "EYE of Storm" - Center void in centrifugal Load Water Vortex.

NOTES:
1. Facility Electrical Power to J-Box and Instrument is not shown.
2. See Dwg. D-35457 for PAU internal component layout.

Clayton

# Dynamometers

## IN GENERAL . . .



### the NEW dynamometer era

Until a few years ago scientific setting of engine performance under various load conditions was restricted to a relatively few engineering laboratories. Although dynamometers are not new, their development is important because it provides industry with an accurate means of guiding the progress and development of gasoline engines, diesel engines and electric motors. Clayton Manufacturing Company has been a pioneer in this progress and for more than a quarter of a century has designed and manufactured profit-making equipment for industry. An outstanding example is the Clayton "Turbo-Closed System" hydraulic dynamometer which makes an important contribution in advancement in the aviation, automotive, marine and industrial fields. With the development of the Clayton Dynamometer, users are provided with the accuracy and dependability of the finest testing equipment available at a fraction of former costs. Today the Clayton dynamometer reduces scientific laboratory test procedure to a simple, mechanical shop operation.

### electric *versus* hydraulic

During the period when the dynamometer was first introduced and during early development stages, it was confined largely to laboratory and experimental work with two types generally in use, the electric and hydraulic groups. The electric group consists essentially of the "generator" and "eddy current" inductor types while the hydraulic group consists of the "fluid friction" and "agitator" types. Both electric types are satisfactory except from the standpoint of size and cost. The popularity of the Hydraulic Type has been due to price advantage and low maintenance cost — as well as its ability to equal the performance of the other more costly types.

### the fluid friction

type hydraulic dynamometer employs one or more rotor discs which revolve between stator discs at close clearances. Power is absorbed through the fluid friction developed between rotor and stator discs. Various torque loads are obtained by varying the volume of fluid (water) between the discs.

To dissipate the heat generated through the absorption of power, a constant flow of water through the dynamometer is required. To maintain a given torque load, this flow must be accomplished without changing the volume of water in the absorption unit. The slightest variation changes the torque load.

As a result, these open flow systems must employ elaborate and sensitive water flow devices in an effort to maintain uniform volume of water within the absorption unit. Even though perfect flow balance is achieved, the return to a base load is impossible without readjustment after power input or speed is varied.

### the agitator

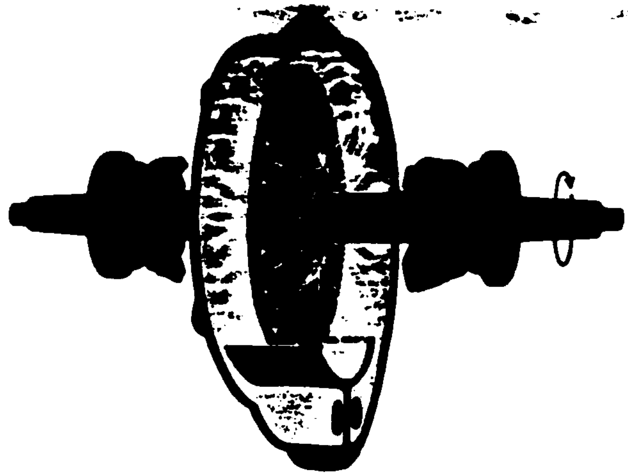
type hydraulic dynamometer absorbs power through the change in momentum of water as it is thrown from the rotor vanes into stator vanes and returned to the rotor. This type follows the cube law, which is an ideal power characteristic since it closely approaches the actual loads applied to all types of engines.

Dissipation of the heat in some types of agitator dynamometers is accomplished by flowing water through the absorption unit which is kept full at all times. Various torque loads are created by sliding gates between the rotor and stator, covering or uncovering vanes to reduce or increase power absorption. While successful from a control standpoint, this type requires more intricate mechanism for its operation. The presence of gates in the working circuit causes a tendency toward turbulence which may result in more rapid erosion of the internal parts.

Other agitator types *vary the amount of water within the machine.* While this method overcomes the necessity for "gate control," it still has the disadvantage of the open flow system described under "fluid frictional" types.

# THERE'S A CLAYTON ENGINE DYNAMOMETER PACKAGE

*designed **and** built for any engine test or run-in requirement . . .*



## comparative

Cost and complications of electric dynamometers and the mechanical shortcomings of the ordinary hydraulic type inspired the Clayton development.

Development of the Clayton dynamometer has been based on the "agitator type" because of the favorable inherent torque characteristics. Improvements in existing design, newly developed principles and perfection of the TURBO-CLOSED system have resulted in a dynamometer of tremendously increased controllability, smoothness of operation, and longer life at a relatively low cost.

The high pumping characteristics of the power absorption unit are utilized to circulate the working fluid through a closed cooling system, in which is incorporated a heat exchanger to dissipate heat generated by power absorption. This is accomplished without changing the quantity of water in the absorption unit. Control of the amount of fluid in the system is effected through the use of quick-opening valves. These developments have resulted in a highly accurate and dependable dynamometer of exceedingly small physical dimensions per unit capacity, whose basic simplicity is highly desirable from a cost maintenance standpoint.

# THE CLOSED SYSTEM

In the Clayton "*TURBO-CLOSED* System" the pumping action of the power absorption unit is used to circulate water through a sealed cooling system and back to the power absorption unit. In the "open flow" system employed by the "fluid friction" and some "agitator" type hydraulic dynamometers water flows into the power absorption unit near its hub and flows out near its periphery as shown below in Figure 1. In the Clayton system properly located inlet and outlet ports provide the circulating passage shown by (A) in Figure 2.

With the rotor in motion, the working fluid is pumped through the closed circulatory passage and back into the unit. The volume of fluid in the working circuit thus remains unchanged and the torque load constant. The Clayton dynamometer may, therefore, be stopped and started without changing the load and will maintain such load until changed by the operator.

## cooling

Heat generated in the working fluid is dissipated by a heat exchanger (B) placed in a closed circulating passage as shown in Figure 3. Here, the fluid is cooled before it is returned to the absorption unit by the circulation of cooling water through the heat exchanger. Since tremendous circulating velocities through the closed system are practical, large quantities of heat may be dissipated with a small, but highly efficient heat exchanger consuming little cooling water.

## maintain constant load

The Clayton "Turbo-Closed System" maintains any *torque* load indefinitely because of its ability to dissipate the heat generated without changing the volume of fluid in the working circuit, an important development in the increased practicability of the hydraulic dynamometer. Vernier control of torque load at any speed is quickly obtained by varying the amount of fluid in the absorption unit simply by opening or closing valves (C) as shown in Figure 4.

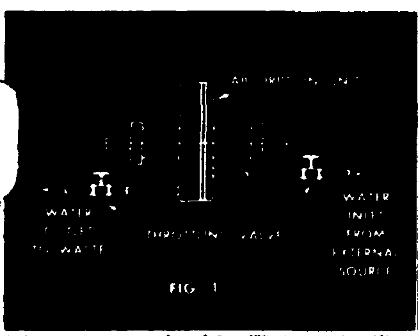


FIG. 1

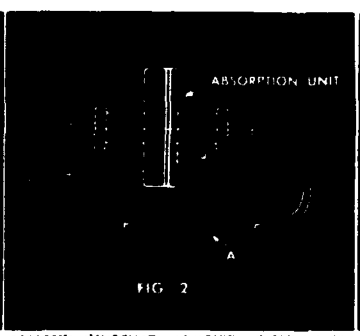


FIG. 2

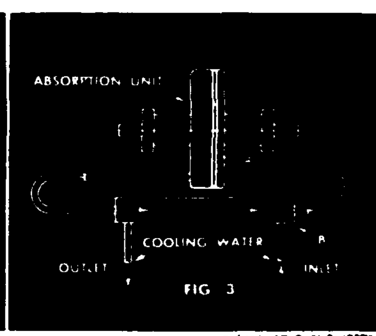


FIG. 3

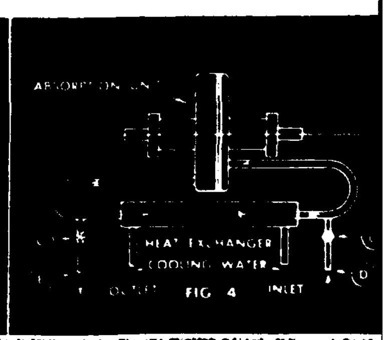


FIG. 4

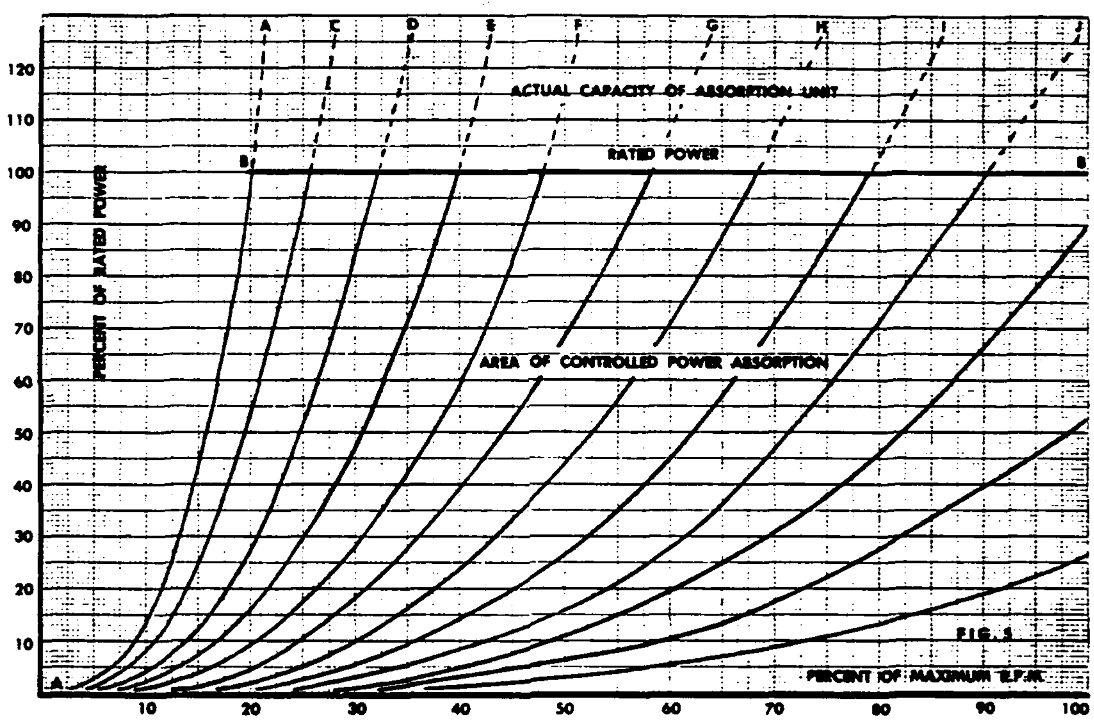
# DESIRABLE POWER CHARACTERISTICS

The cube curve (Line AA in FIGURE 5) shows the maximum capacity of a typical Clayton power absorption unit. It will be noted that the partial load characteristics, shown by the family of curves AC, AD, etc., closely follow the cube (propeller) law as is the case with the maximum power curve AA. Because any one of this family of curves, infinite in number, can be selected by varying the volume of water in the absorption unit. the dynamometer has a useful range from low speeds to extreme high speeds. The horizontal line BB shows the continuous power absorption capacity of the entire dynamometer. While the absorption units are always capable of greater power than represented by line BB, the rated power of the machine is of necessity limited by the absorption unit shaft size and the capacity of the cooling system.

The fact that the absorption unit curve does not flatten out as it approaches the rated power of the dynamometer is an advantage, as the dynamometer power speed curve will cross the average prime mover curve at a wide angle, which reduces the tendency to "hunt or surge."

## acceleration tests

Since the inherent characteristics of the Clayton power absorption unit follow the cube law, normal acceleration tests are easily performed. The rotating inertia of Clayton power absorption units is extremely low, resulting in immediate responses in engine's loads and performance.




## instrumentation

*Accuracy in any type of dynamometer depends upon the ability to hold a constant load, proper cradling of dynamometer stator, and the instrumentation employed. In the Clayton design all stator movement restriction is held to a minimum and since ability to hold a constant load is exceptionally high in the Clayton dynamometer, the accuracy obtained is dependent only upon instrumentation employed.*

*All Clayton dynamometers are built to operate with either the finest of laboratory instruments or standard service instruments.*

## tachometers

*The direct reading tachometers normally provided with Clayton dynamometers perform with an accuracy of within plus or minus 1% to 2%. Other types of tachometers may be used also.*

## torque scales

*Clayton dynamometers equipped with torque scales provide an accuracy of torque reading of within one-half of 1%. Other types of torque scales with varying degrees of accuracy can be used with Clayton dynamometers.*

## direct reading horsepower

*In dynamometer applications where immediate indication of horsepower without mathematical computation is an advantage, the exclusive Clayton direct-reading horsepower meter is available — providing an accuracy of within 3½%.*

**CLAYTON MANUFACTURING COMPANY**

EL MONTE, CALIFORNIA • CINCINNATI, OHIO

C 732 8 5M/5-69/PP

PRINTED IN U.S.A.

# APPENDIX E

## CHRYSLER PRESENTATION - KNOCK SENSORS

# Knock Sensor Use On Chrysler Corporation Vehicles

| | Recommended Fuel |
|---|---|
| • 1992 MY 2.5L Turbo | 97 RON |
| • 1992 MY 2.2L DOHC Turbo | 97 RON |
| • 1993 MY 3.5L SOHC V6 | 93 RON |
| • Future Four Cylinder | 91 RON |

# Knock Sensor Justification

**Regular Fuel Engines:**

- Protection from tolerances and build variations
- Protection for extreme operating conditions
- Compensation for engine age and carbon accumulation
- Protection from poor fuel quality
- Protection for poor cylinder-to-cylinder fuel/air distribution

**Premium Fuel Engines:**

- same conditions as above
- To permit increased engine performance when operated on premium fuels

# Knock Sensor Types

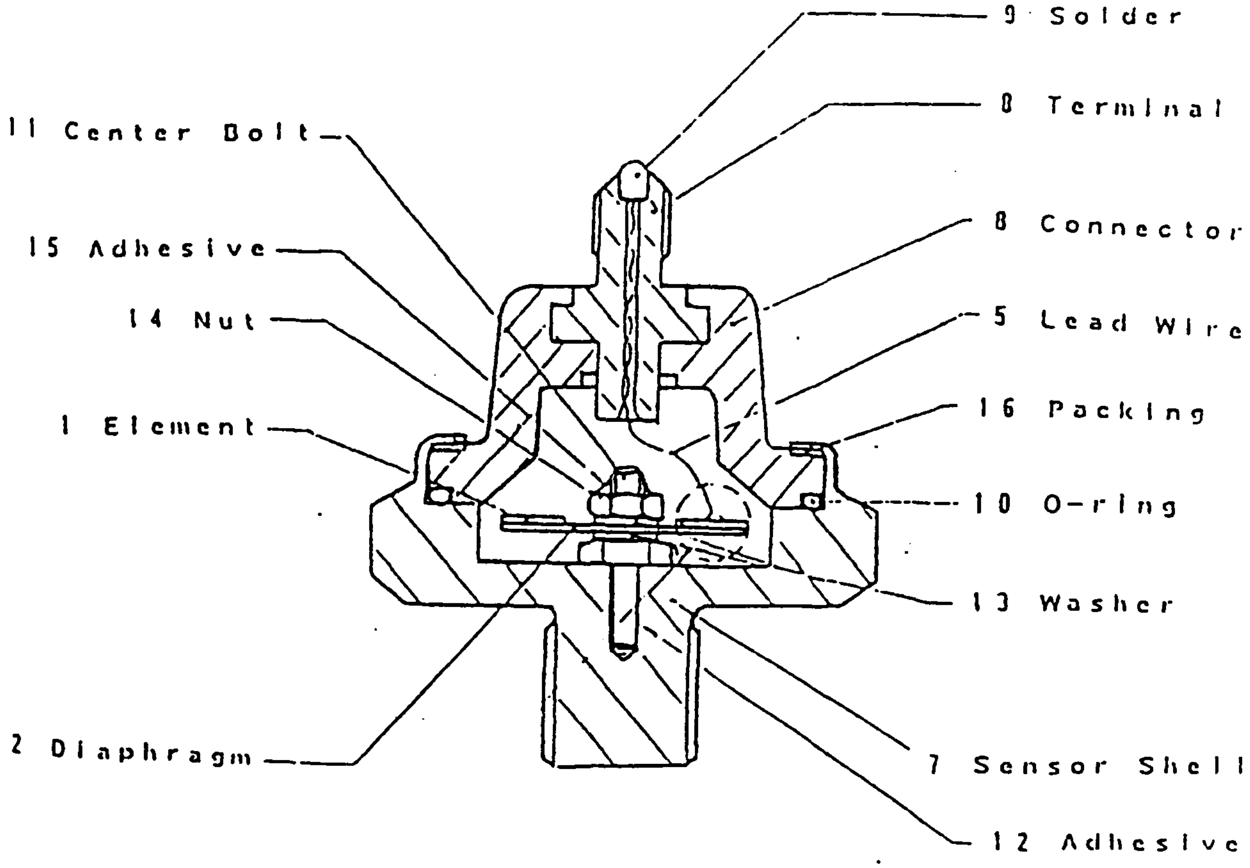
## "**<u>Narrow Band</u>**"

Sensor that is "tuned" to resonate at a frequency corresponding to the frequency of the vibration of engine block when knock is present.

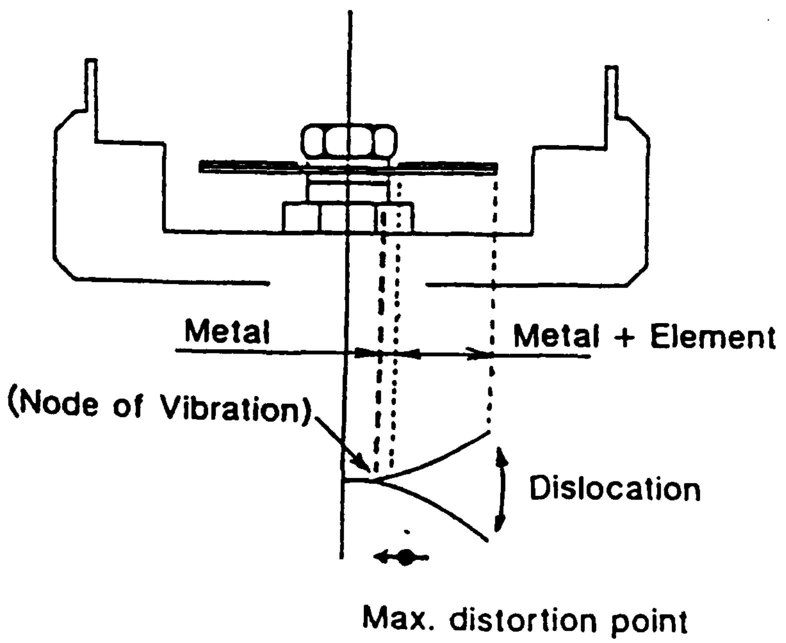
## "**<u>Broad Band</u>**"

Sensor that responds to all engine block vibration frequencies equally. Similar in output to an accelerometer.

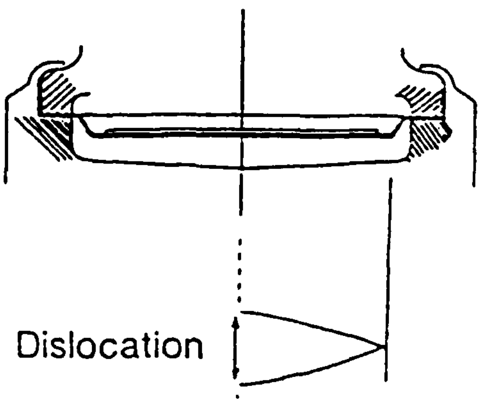
# KNOCK SENSOR STRUCTURE




Current Design

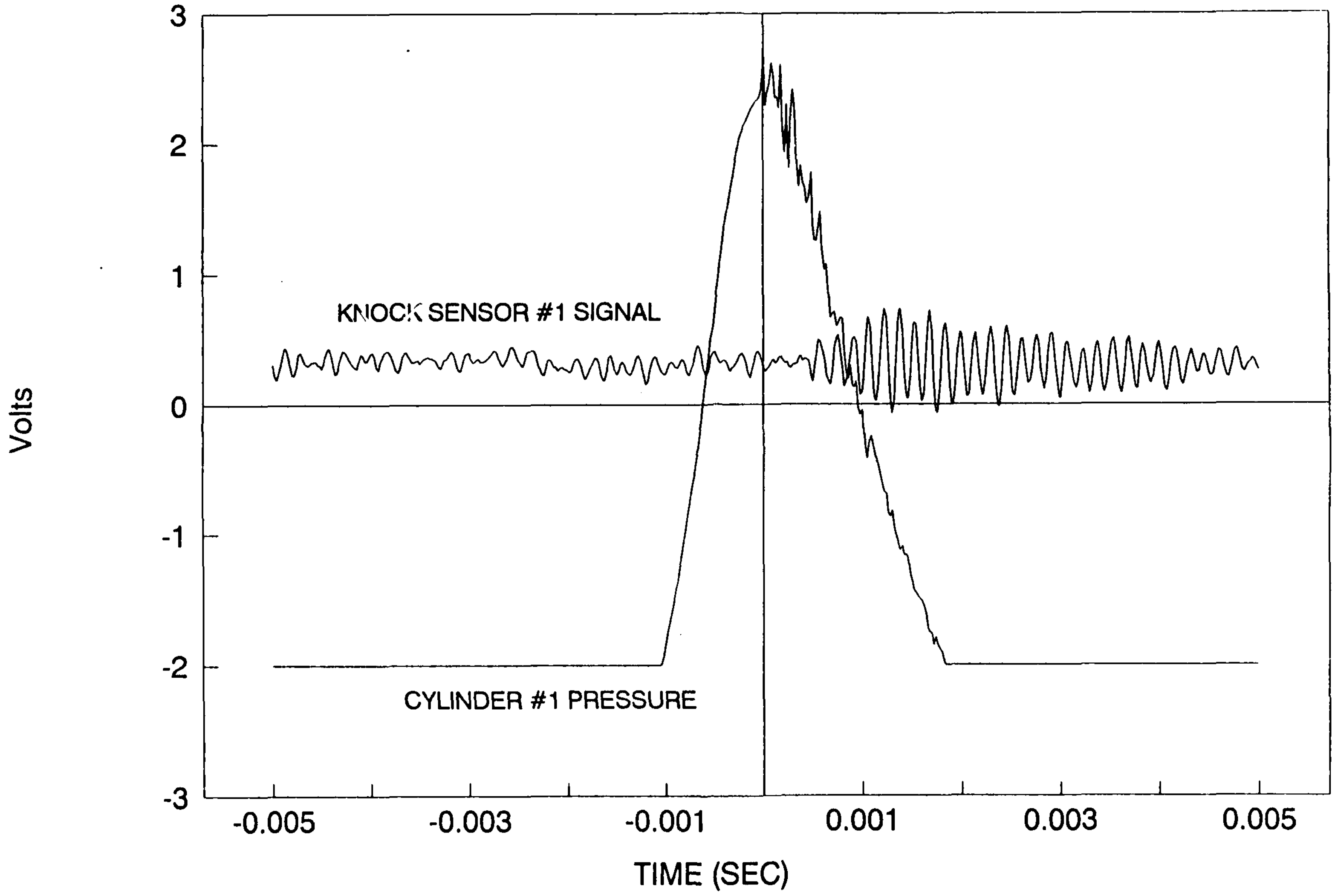


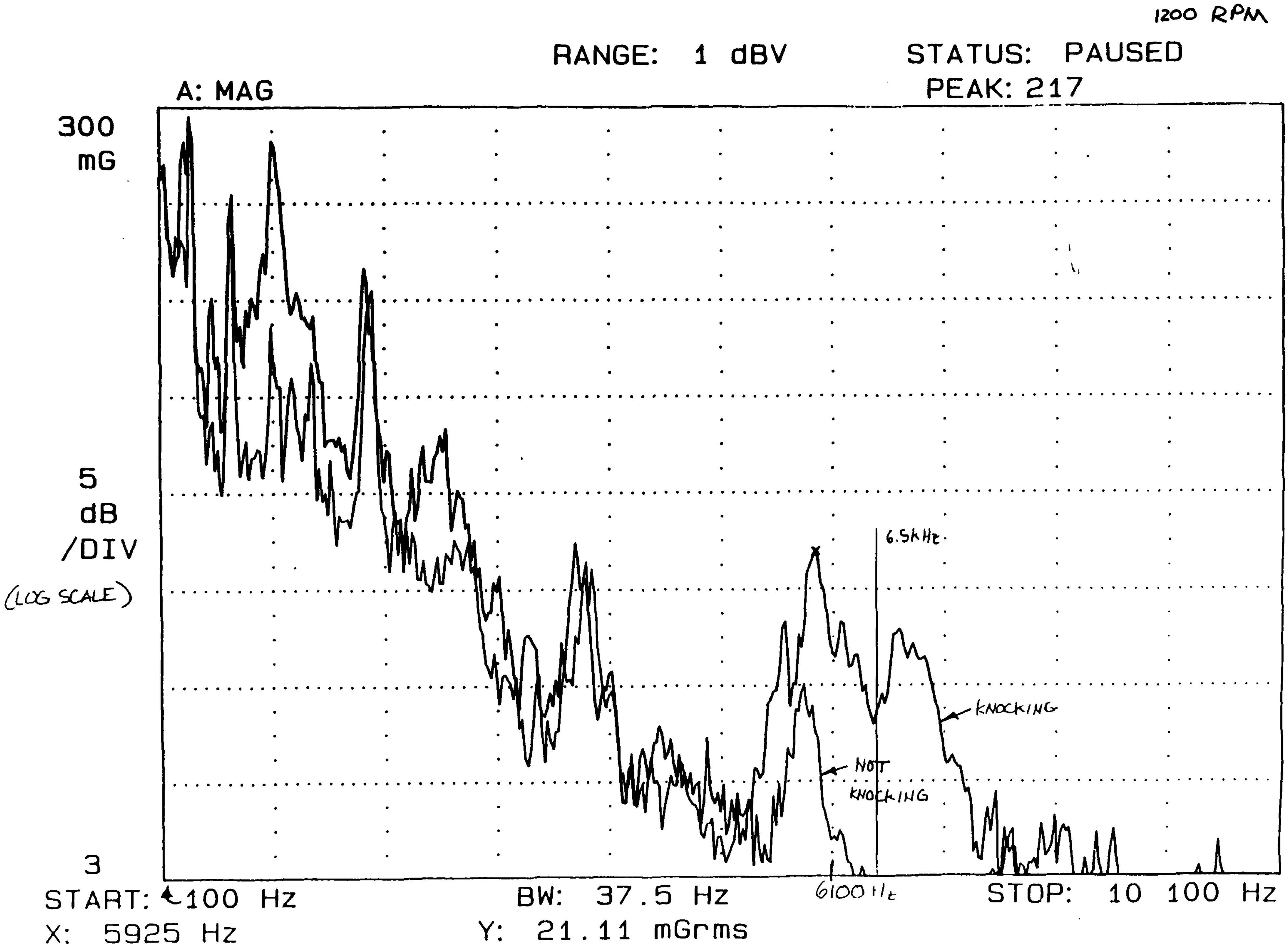

Cf. Circumference Clamping



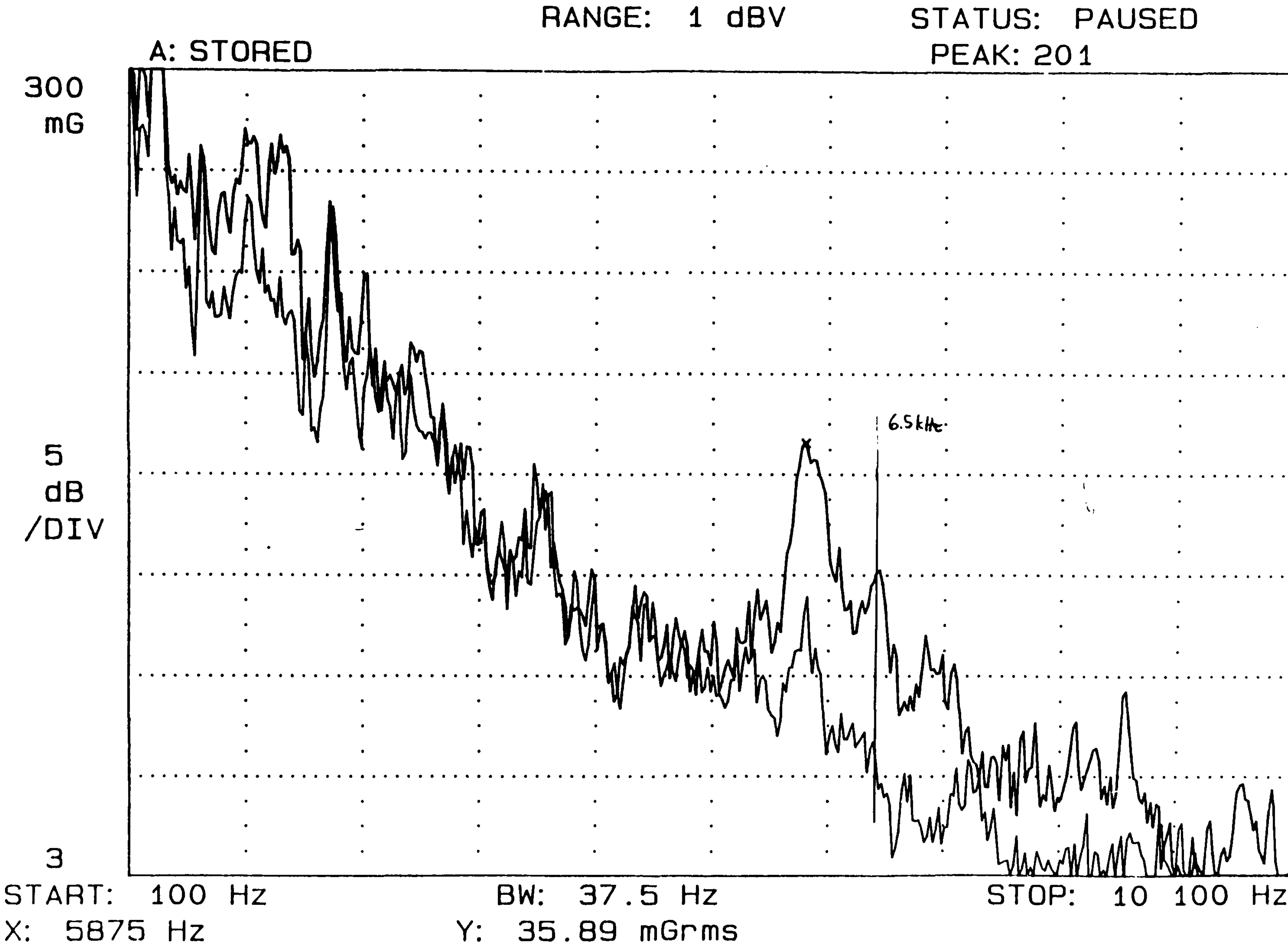
## KNOCK TESTING

2800 RPM, WOT, 4/17/90

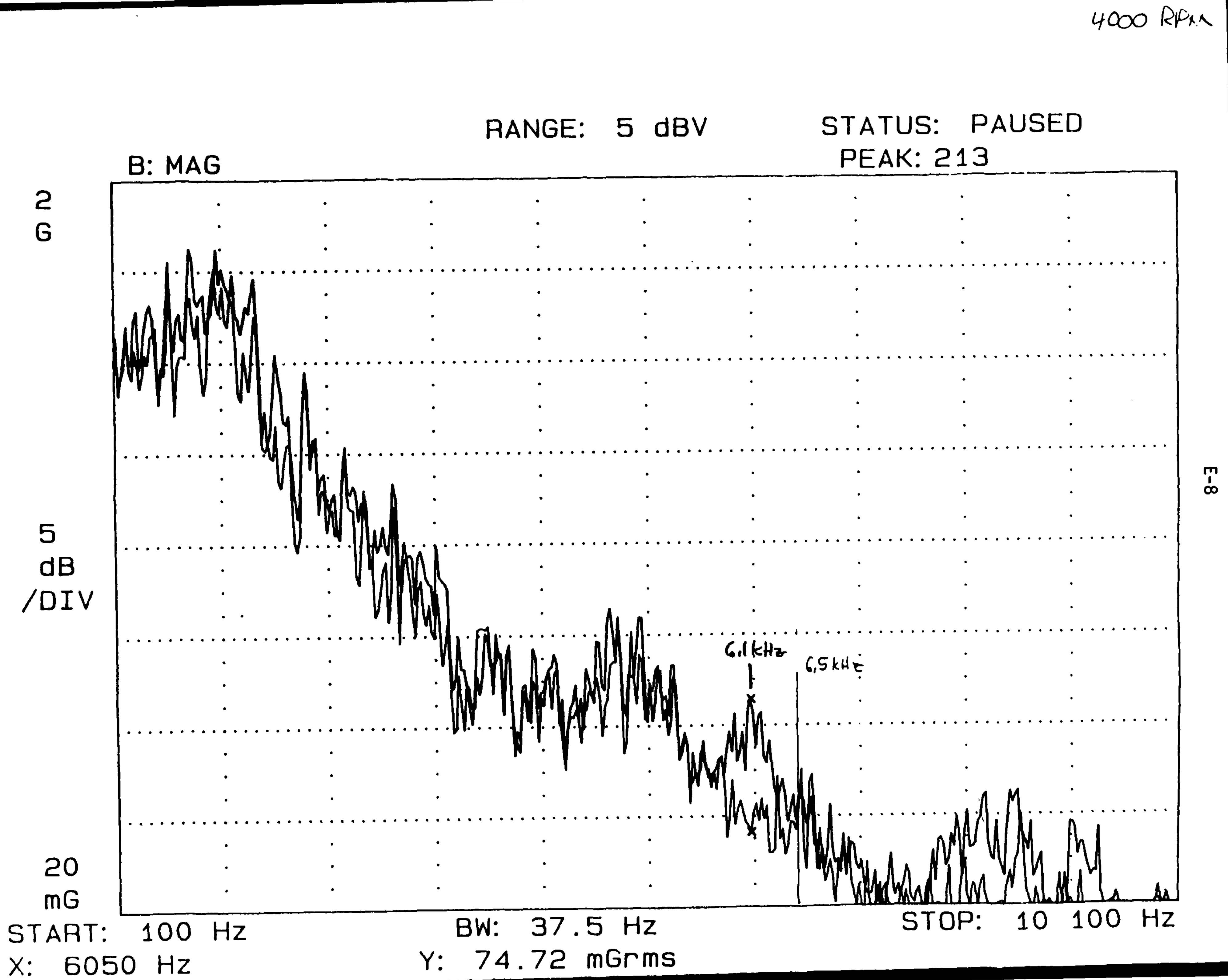


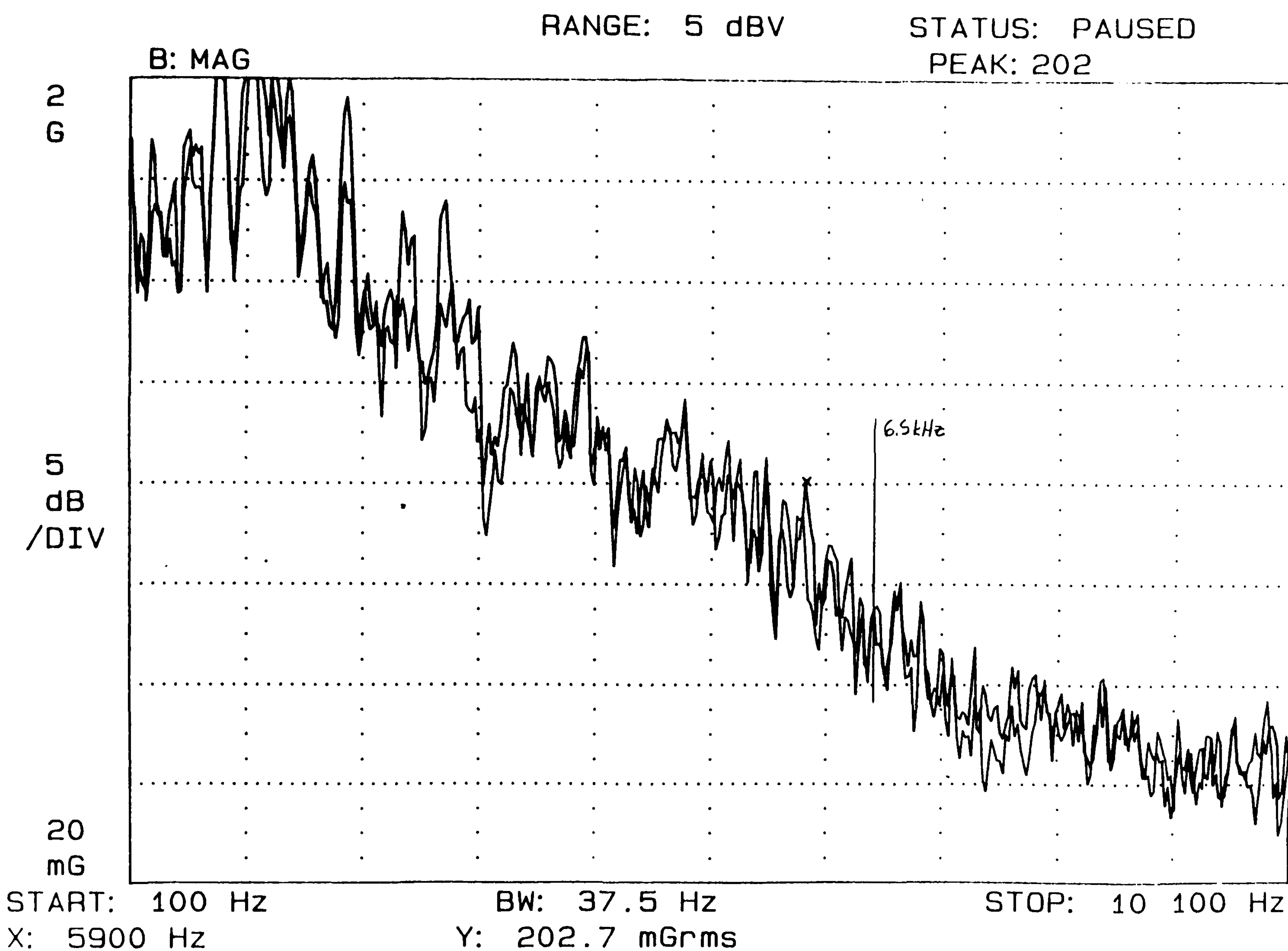

1200 RPM
RANGE: 1 dBV
STATUS: PAUSED
PEAK: 217
A: MAG
300
mG
5
dB
/DIV
(LOG SCALE)
3
6.5kHz
KNOCKING
NOT
KNOCKING
6100 Hz
START: 100 Hz
BW: 37.5 Hz
STOP: 10 100 Hz
X: 5925 Hz
Y: 21.11 mGrms

2000 RPM

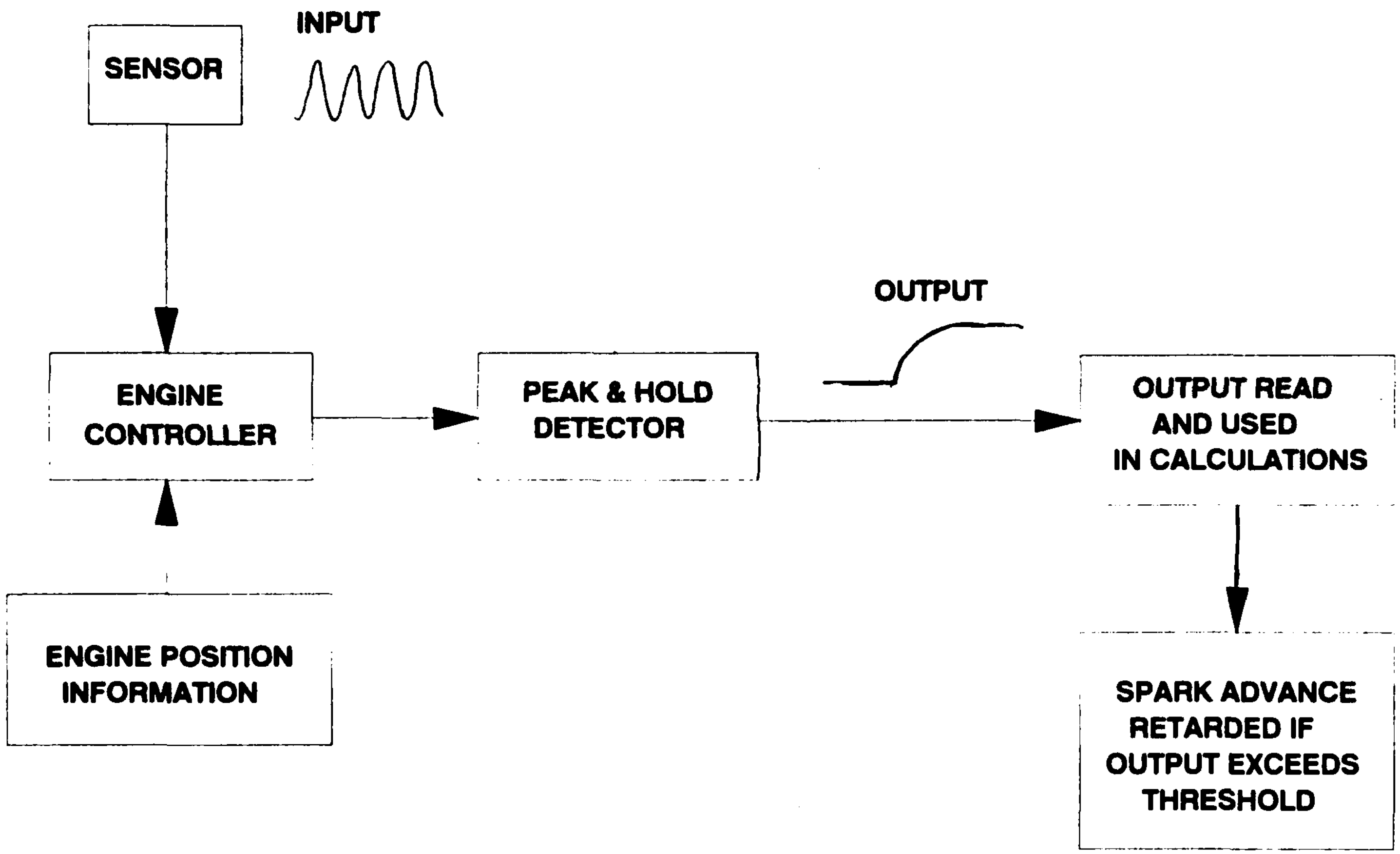


RANGE: 1 dBV
STATUS: PAUSED
A: STORED
PEAK: 201
300
mG
5
dB
/DIV
3
6.5 kHz
START: 100 Hz
BW: 37.5 Hz
STOP: 10 100 Hz
X: 5875 Hz
Y: 35.89 mGrms


4000 RPM
RANGE: 5 dBV
STATUS: PAUSED
PEAK: 213
B: MAG
2
G
5
dB
/DIV
20
mG
6.1kHz
6.5kHz
START: 100 Hz
X: 6050 Hz
BW: 37.5 Hz
Y: 74.72 mGrms
STOP: 10 100 Hz


5600 RPM
RANGE: 5 dBV
STATUS: PAUSED
PEAK: 202
B: MAG
2
G
5
dB
/DIV
20
mG
6.5kHz
START: 100 Hz
BW: 37.5 Hz
STOP: 10 100 Hz
X: 5900 Hz
Y: 202.7 mGrms

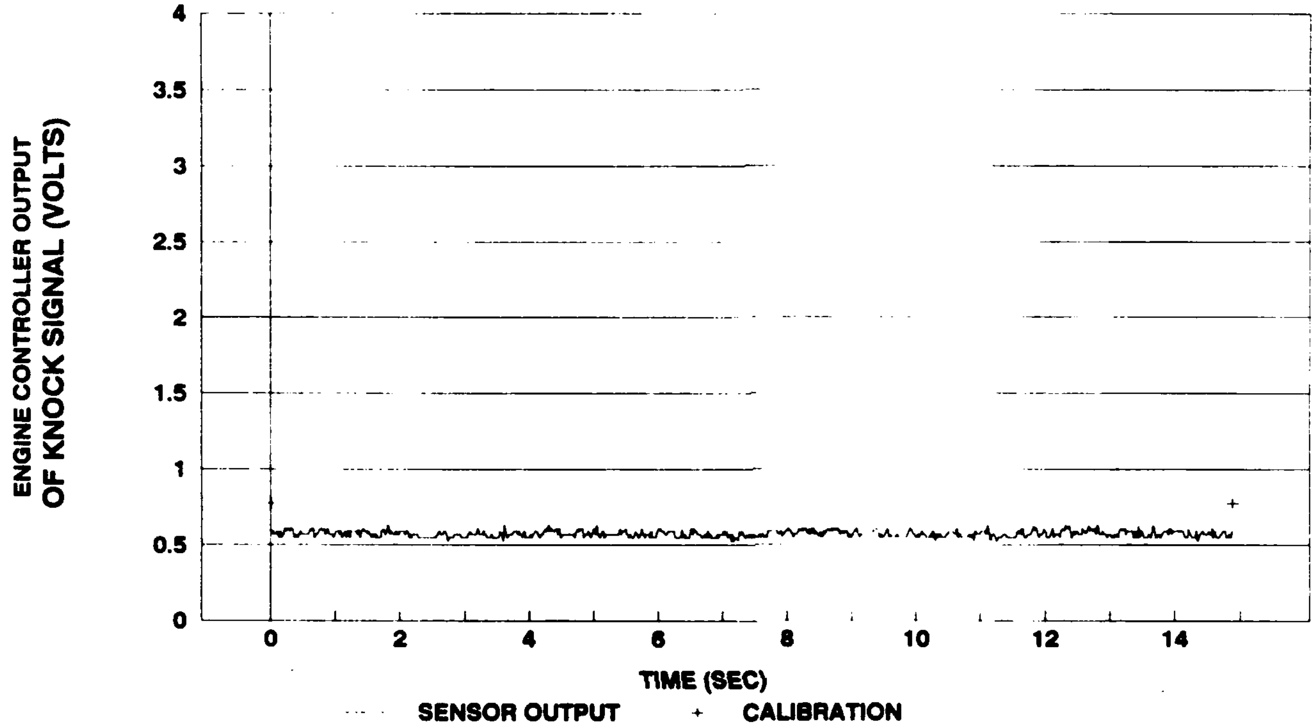
# BASIC CHRYSLER KNOCK CONTROL SYSTEM



# KNOCK SYSTEM OUTPUT

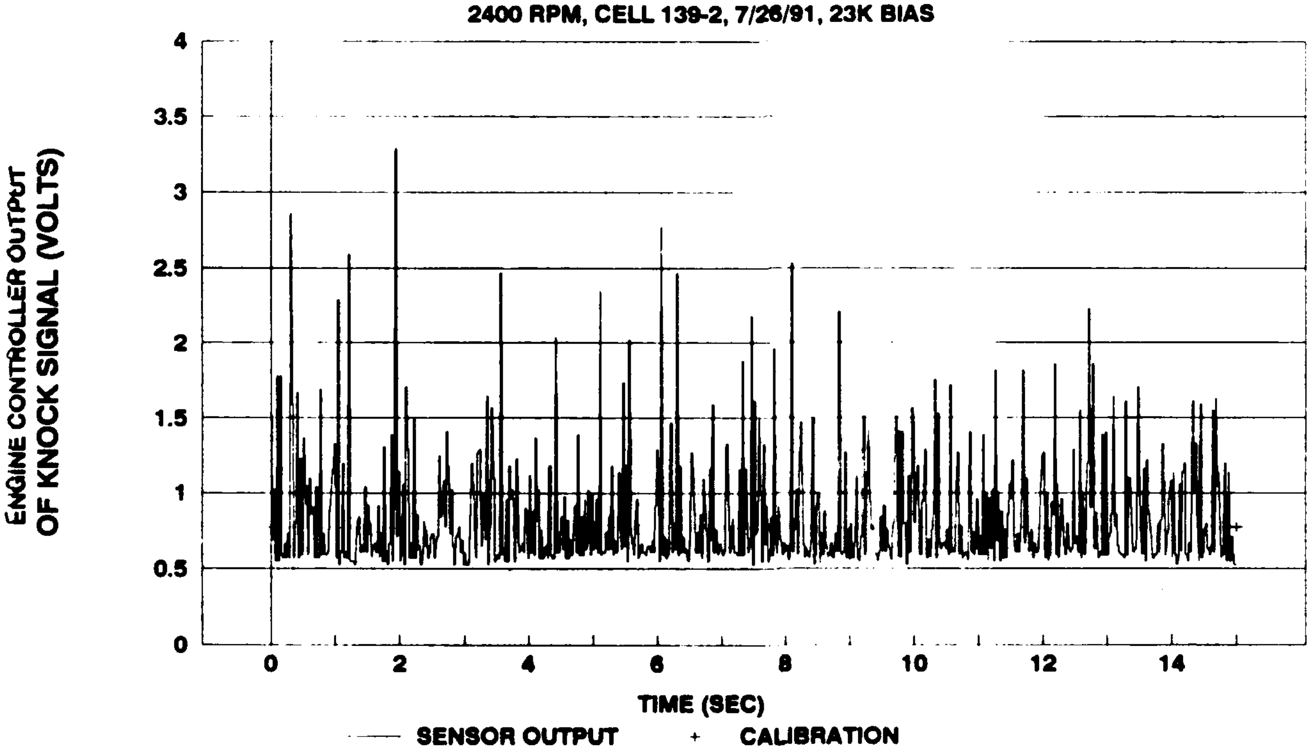
## 97 RON (NOT KNOCKING)

2400 RPM, CELL 139-2, 7/26/91. 23K BIAS




## 91 RON (KNOCKING)

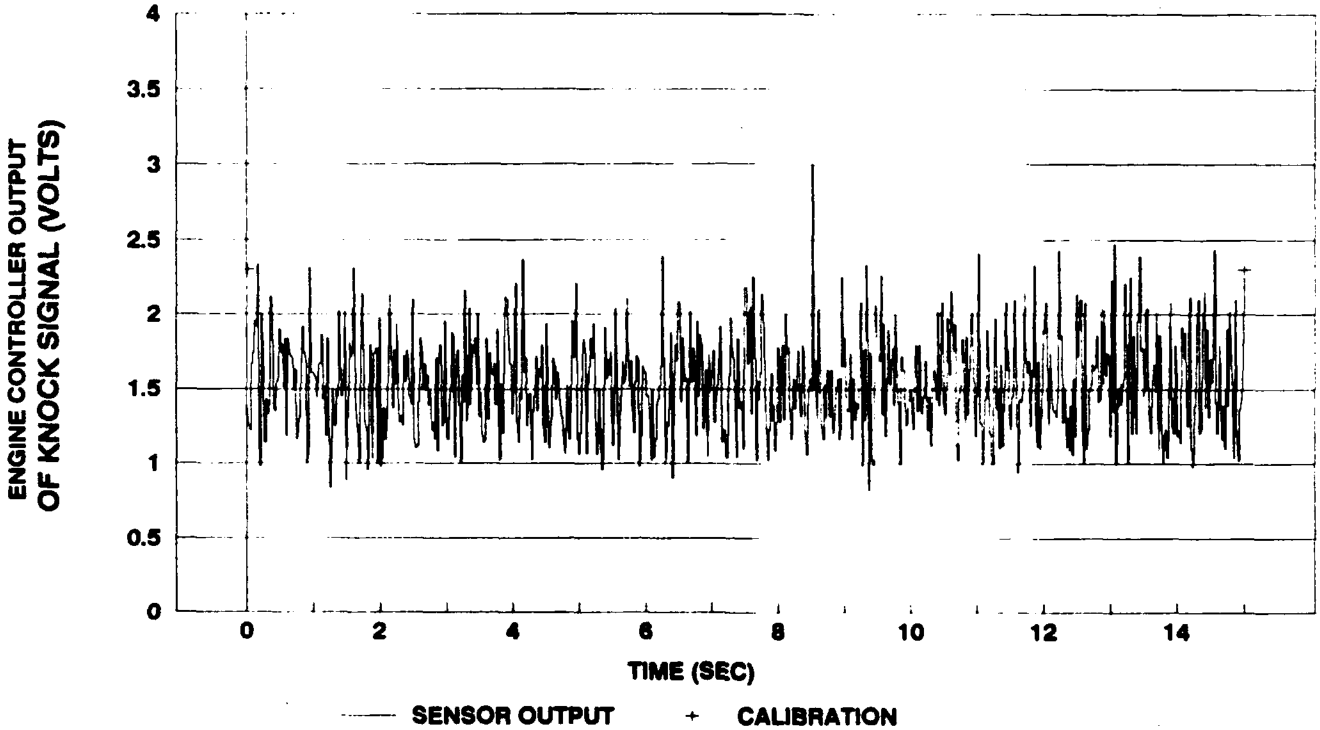
2400 RPM, CELL 139-2, 7/26/91, 23K BIAS



# KNOCK SYSTEM OUTPUT

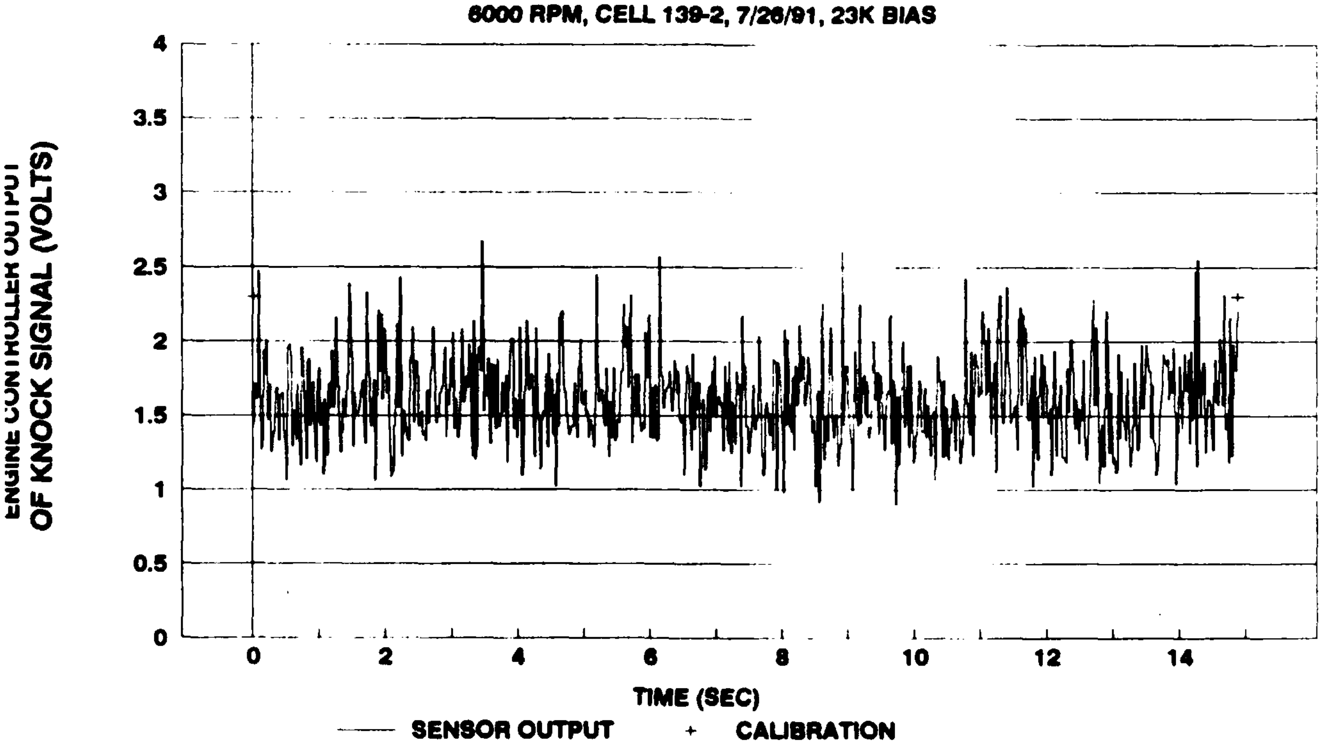
## 97 RON (NOT KNOCKING)

6000 RPM, CELL 139-2, 7/26/91. 23K BIAS

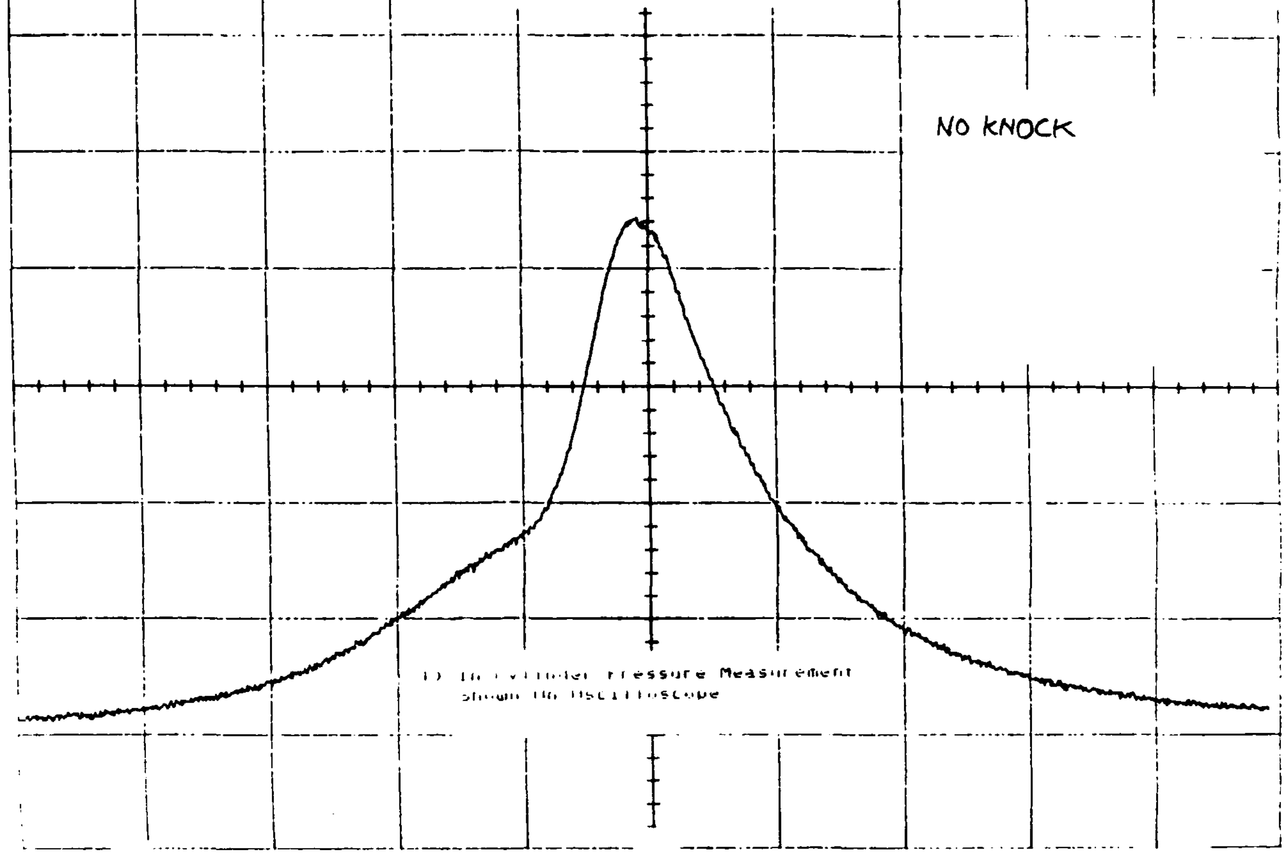


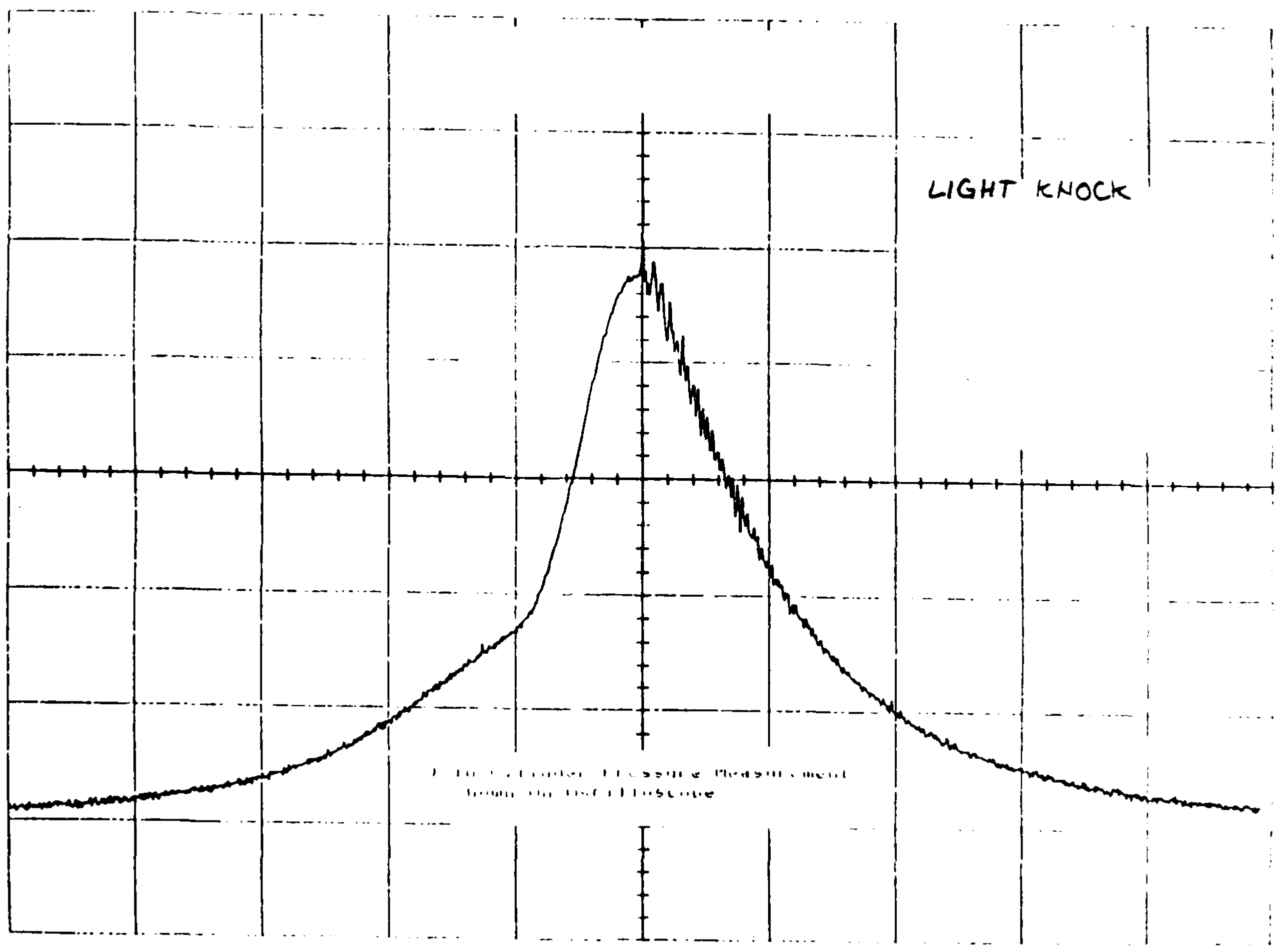

## 91 RON (KNOCKING)

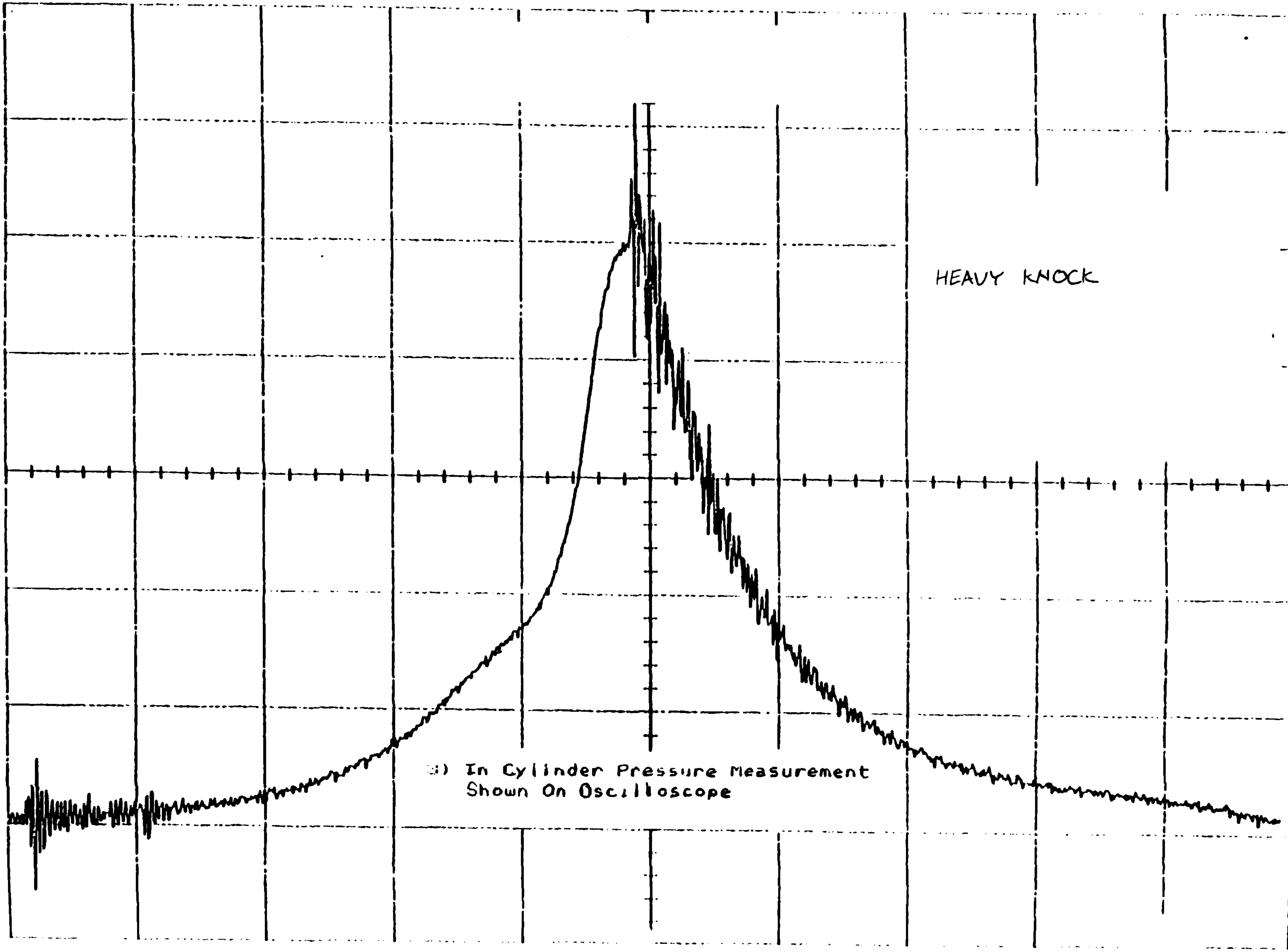
6000 RPM, CELL 139-2, 7/26/91, 23K BIAS



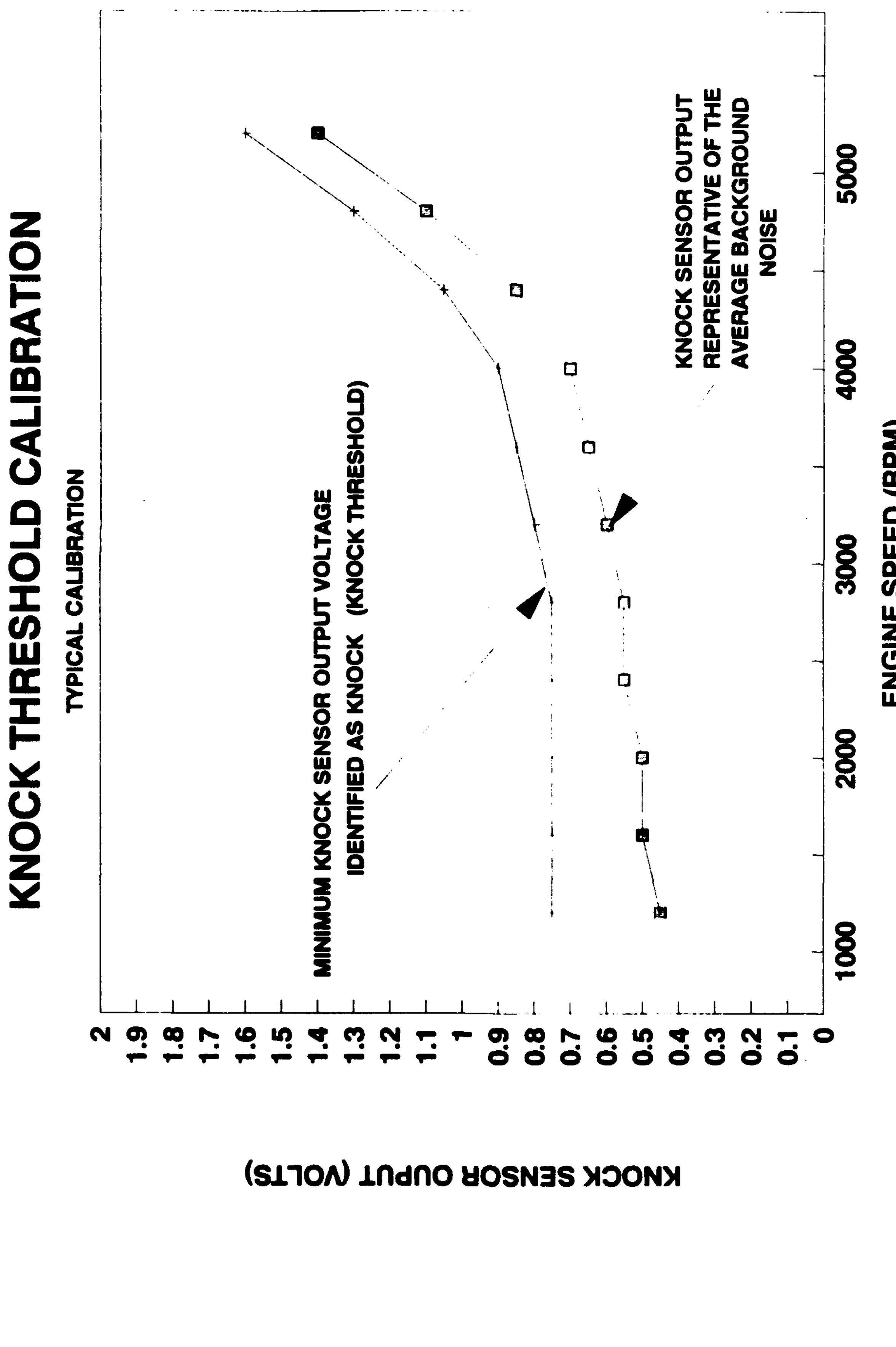
# CYLINDER PRESSURE



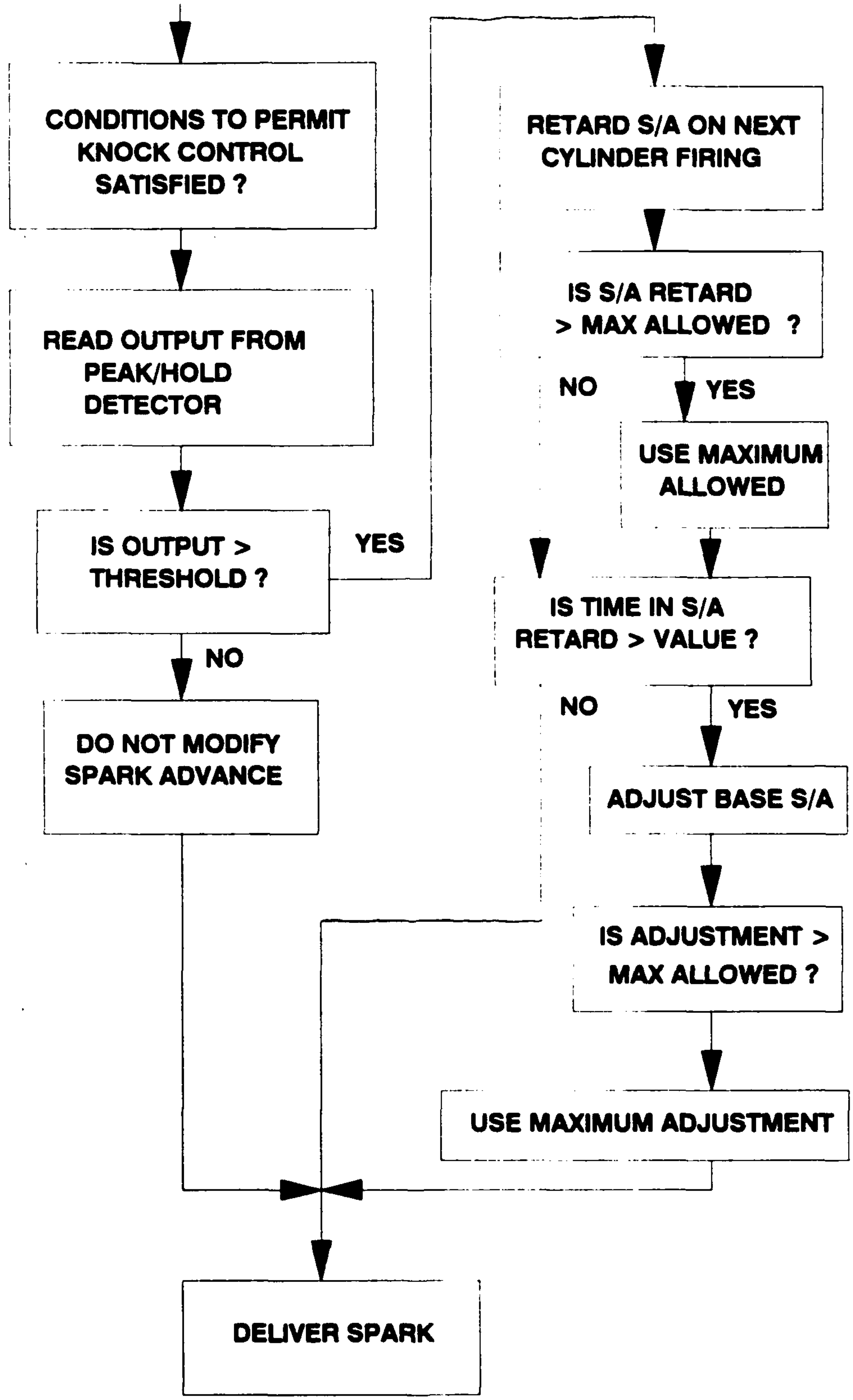






B) In Cylinder Pressure Measurement Shown On Oscilloscope


KNOCK THRESHOLD CALIBRATION
TYPICAL CALIBRATION
MINIMUM KNOCK SENSOR OUTPUT VOLTAGE
IDENTIFIED AS KNOCK (KNOCK THRESHOLD)
KNOCK SENSOR OUTPUT
REPRESENTATIVE OF THE
AVERAGE BACKGROUND
NOISE
ENGINE SPEED (RPM)
1000
2000
3000
4000
5000
KNOCK SENSOR OUPUT (VOLTS)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2

# CHRYSLER KNOCK CONTROL STRATEGY

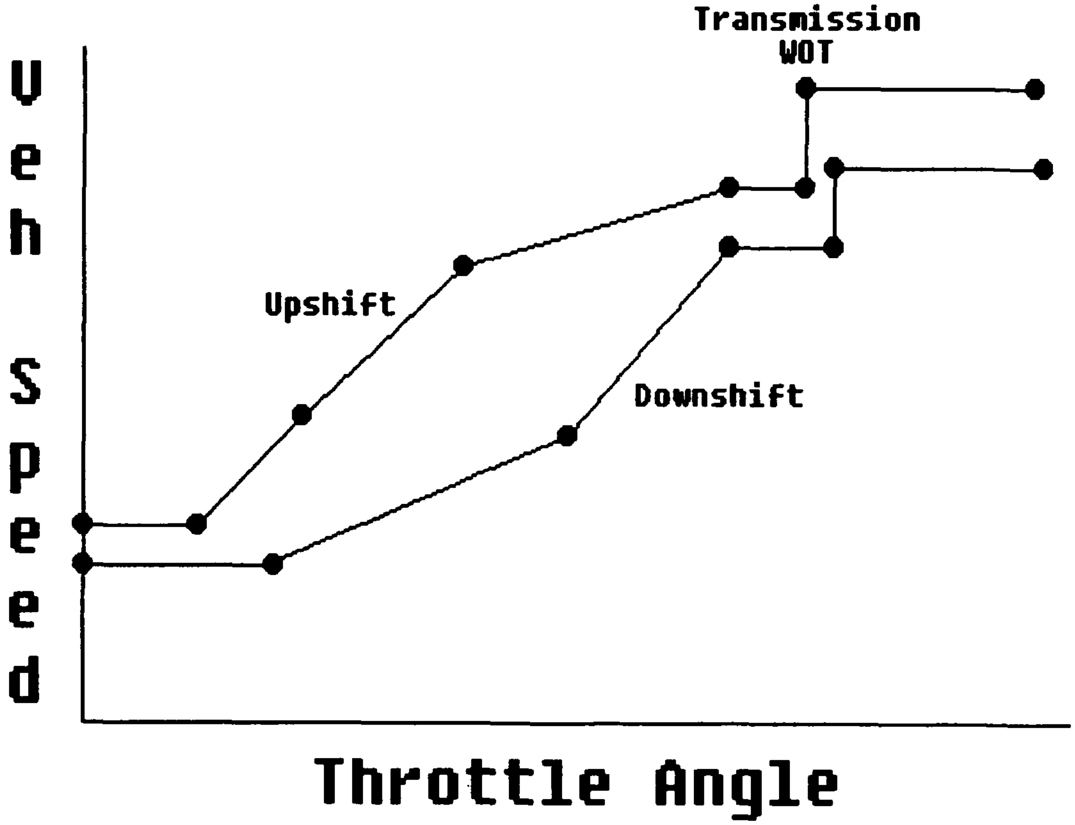


# APPENDIX F

## FORD MOTOR COMPANY PRESENTATION

## AUTOMATIC TRANSMISSION

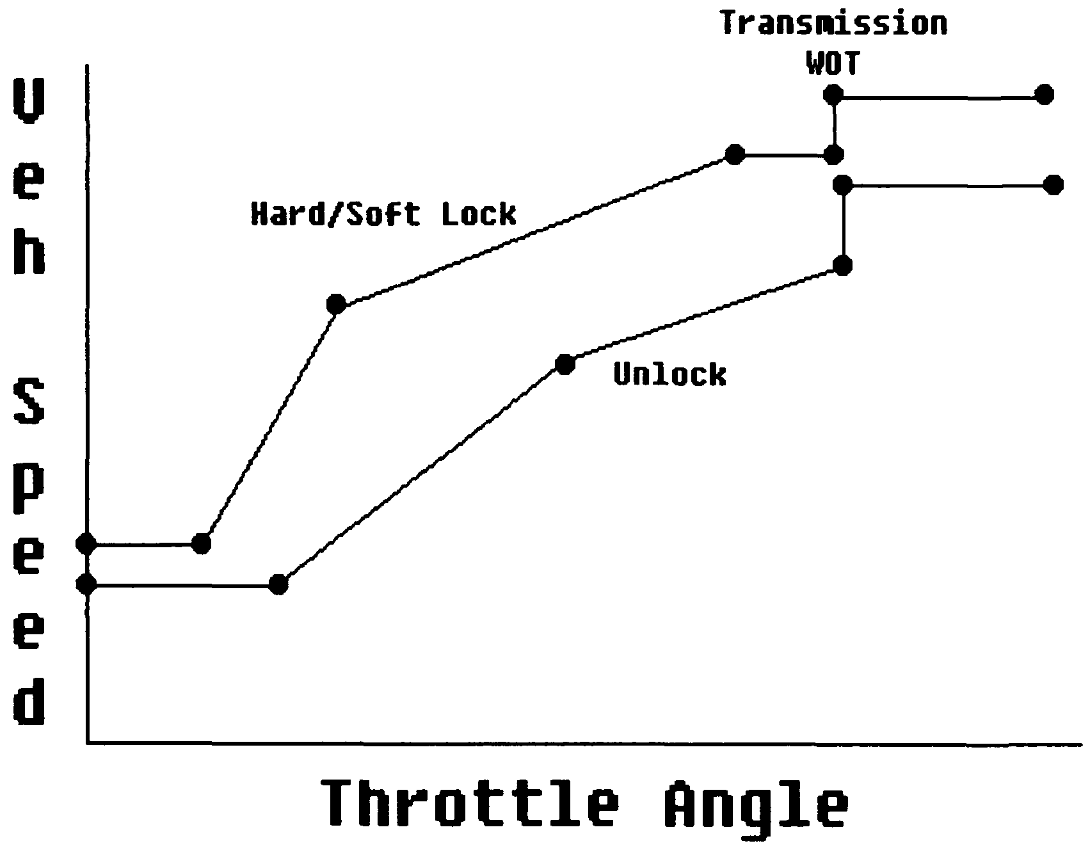
Shift points in *FORD* electronically controlled automatic transmissions are scheduled PRIMARILY on Throttle Angle and Vehicle (output shaft) Speed.




Deviations are made based on:

- Barometric Pressure (Altitude).
- Transmission Temperature.
- Vehicle Acceleration Rate.

Converter clutch operation in *Ford* electronically controlled automatic transmissions is scheduled base on Throttle Angle and Vehicle (Output Shaft) Speed. The three primary modes of operation are Open (unlocked), Locked (Full Lockup - No Slip), and Soft Lock (Controlled Slip).




Deviations are made based on:

- Barometric Pressure (Altitude).
- Transmission Temperature.

Additionally, the converter clutch can be unconditionally unlocked for any of the following conditions: Closed Throttle, Throttle Rate of Change, Brakes Applied, and Low Transmission Temperature.

# APPENDIX G

## FORD MOTOR COMPANY PRESENTATION

## KNOCK SENSORS

# Why use a Knock Sensor(s)?

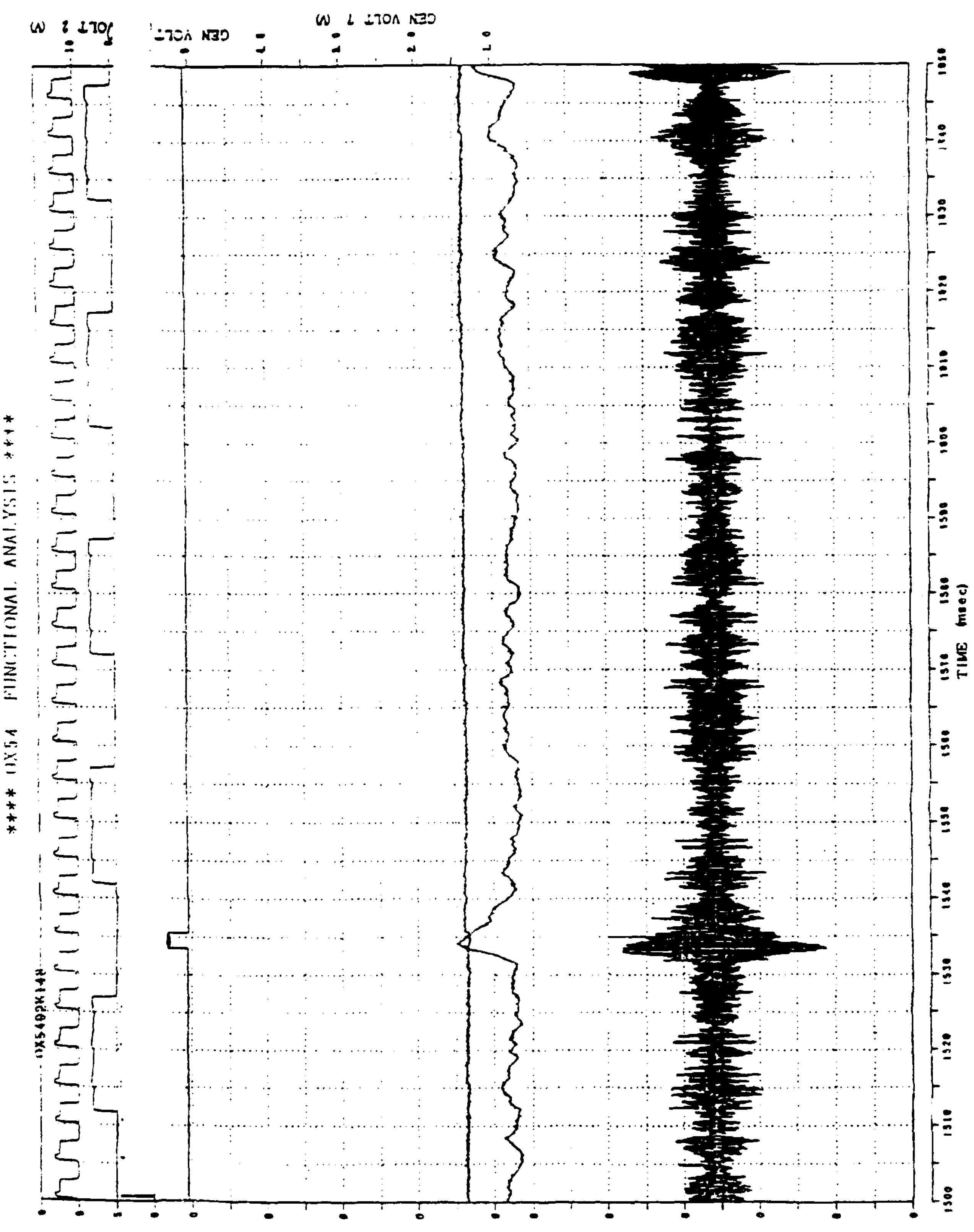
- Reduces customer complaints regarding detonation
- Allows somewhat more advanced spark
- Protects engine at high RPM
- Protects against low octane on "Premium Only" vehicles

# How Do Knock Sensors Work?

1) Sensor directly measures the acceleration of the engine at a particular location.

2) Circuitry processes the sensor signal and detects the presence of detonation.

3) Electronic processor recognizes the presence or absence of knock and adjusts the spark accordingly.


**** OX54 FUNCTIONAL ANALYSIS ****
TIME (msec)

# Requirements for a Properly Working Knock System:

1) The sensor location itself provides adequate distinction between knocking and non-knocking conditions.
2) The sensor is tuned to the proper frequency.
3) The system has been calibrated adequately for detecting knock.
4) The system has been calibrated adequately for reacting to knock.
5) The engine vibration characteristics do not change significantly over time.

# How Drastically Can the Knock Sensor Affect Spark?

1) Depends upon each application:

- Some applications only allow the knock sensor to change spark by 2 degrees. This would not affect vehicle performance.

- Others allow up to 8 degrees retard. This may make the engine response more sluggish and could reduce engine power output by a noticeable amount.

2) Sensor failures result in most advanced spark effect:

- Customer complaints of engine knock could indicate a failed knock sensor, although this sensor does not frequently fail on current applications.

- Knock Sensor failures <u>are not</u> the cause of customer complaints regarding lack of power.

## Current Ford Applications with Knock Control

- All 4.9L Trucks
- All 5.0L Trucks
- 3.8L Super Coupe
- 3.0L Taurus SHO

## Future Knock Applications

- 1993 4.6L-4V Mark VIII
- 1993 3.2L Taurus SHO

# APPENDIX H

## BONNEVILLE ONR DATA

ONRS-92
Side C

Sheet____of____Sheets

**1992 CRC OCTANE NUMBER REQUIREMENT SURVEY - 1992 MODEL VEHICLES**
**CONTINUATION SHEET**

Company:

Date: 5 - 19

Vehicle Make: PONTIAC

Model: BONNEVILLE

V.I.N.:

License No.:

TO BE FILLED IN BY CRC: Observation No.:____-____

| Reference Fuel | | Test Gear No. (12) | Throttle Position (16) | Man. Vac. Hg/psig (13) | Max. Knock Intensity (10) | | | (10) | Speed Range, RPM | | RPM of Max. of Intensity |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Series | Res. O.N. | | | | Acceleration 1 | 2 | 3 | Final Rating | Knock In | Knock Out | |
| KS ON | 86 | 4L | M | | N | N | | N | | | |
| | | 4U | M | | N | N | | N | | | |
| | | 3 | M | 1.5 | B | B | | B | 2300 | 2900 | 2600 |
| | | 2 | M | .5 | B | B | | B | 3200 | 3600 | 3500 |
| | | 3 | P | 3.0 | B | B | | B | 2300 | 2600 | 2400 |
| | 88 | 3 | M | | B | B | | B | 2700 | 2900 | 2800 |
| | | 2 | M | | B | B | | B | 3400 | 3600 | 3500 |
| | | 3 | P | 3.0 | B | N | B | B | 2400 | 2500 | 2455 |
| KS OFF | | | | | | | | | | | |
| | 88 | 4C | M | 1.0 | B | B | | B | 1350 | 1700 | 1500 |
| | | 4 | M | 1.0 | B | B | | B | 1600 | 1800 | 1700 |
| | | 3 | M | 1.5 | A | | | A | | | |
| | | 2 | M | 3.5 | A | | | A | | | |
| | | 3 | P | 3.0 | B | B | | B | 2400 | 2500 | |
| | 92 | 4C | M | | N | B | N | N | | | |
| | | 4 | M | | N | N | | N | | | |
| | | 3 | M | | N | N | | N | | | |
| | | 2 | M | | B | A | | A | | | |
| | | 3 | P | | N | N | | N | | | |
| KS ON | 92 | 2 | M | | N | B | N | N | | | |
| | | | | | | | | | | | |

Side D

| Reference Fuel | | Test Gear No. (12) | Throttle Position (16) | Man. Vac. Hg/psig (13) | Max. Knock Intensity (10) | | | (10) | Speed Range, RPM | | RPM of Max. of Intensit, |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Series | Res. O.N. | | | | Acceleration | | | Final Rating | Knock In | Knock Out | |
| | | | | | 1 | 2 | 3 | | | | |
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## LEGEND

(1) R = Road; C = Chassis Dynamometer
(2) e.g. V8, L4, R for Rotary
(3) F = Federal; C = California;
A = Altitude; B = "C" and "A"
E = Everything
(4) T = Turbocharged; S = Supercharged
(5) Number of Carb. Venturis or T for throttle body injection or P for port injection
(6) A = Automatic; M = Manual
(7) Record number of transmission speeds
(8) + = BTDC; - = ATDC
(9) Y = Yes; N = No; O = Objectionable
(10) N = None; B = Borderline; A = Above Borderline
(11) M = Maximum-Throttle;
P = Part-Throttle higher than Maximum-Throttle Requirement
(12) If vehicle is equipped with converter clutch, in addition to gear number, indicate U for unlocked and L for locked (e.g., 3U)
(13) If boost pressure greater than atmospheric, use Manifold Pressure (psig) with minus sign (-); when fanning, write in "FAN"
(14) Applies only to knock-sensor vehicles.
(15) If ONR not bounded by test fuels,
L = Less than lowest available fuel;
H = Higher than highest available fuel.
If part-throttle requirement is greater than four numbers below maximum-throttle requirement, enter F.
If above does not apply and ONR is not determined, enter U.
(16) Record M for Maximum-Throttle, P for Part-Throttle, or FAN if fanning

## COMMENTS

ONRS-92
Side C

Sheet ___ of ___ Sheets

**1992 CRC OCTANE NUMBER REQUIREMENT SURVEY - 1992 MODEL VEHICLES**
**CONTINUATION SHEET**

Company: CRC  Date: 5-20-92

Vehicle Make: PONTIAC  Model: BONNEVILLE

V.I.N.: ______  License No.: ______

TO BE FILLED IN BY CRC: Observation No.: ___-___

| Reference Fuel Series | Reference Fuel Res. O.N. | Test Gear No. (12) | Throttle Position (16) | Man. Vac. Hg/psig (13) | Max. Knock Intensity (10) Acceleration 1 | Acceleration 2 | Acceleration 3 | (10) Final Rating | SPK ADV. | Speed Range, RPM Knock In | Speed Range, RPM Knock Out | RPM of Max. of Intensity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 92 | 2 | M | .5 | Y 2 N | Y 1 N | N 0 N | N | 17° | | | |
| | 90 | 2 | M | .5 | Y 2 N | N 1 N | Y 1 N | N | | | | |
| | 88 | 2 | M | .5 | Y 2 N | Y 3 N | Y 3 B | N | | | | |
| | 86 | 2 | M | .5 | Y 4 N | Y 3 B | Y 5 N | N | | 2400 2900 | 2500 3000 | |
| | 82 | 2 | M | .5 | Y 6 B | Y 6 A | Y 6 B | A | 10° | 2300 | 2500 | |
| | 84 | 2 | M | .5 | Y 4 B | Y 5 B | | B | 10°-15° | 2800 2400 | 3000 2500 | |

OTC 4000 USED FOR KNOCK SIGNAL Y/N → Y

SPARK RETARD DEG. → B 4

SPARK ADVANCE DEG.

SPK. ADV. WOT @ 3000 RPM KS OFF 16°

3500 17°

4000 22°

4500 27°

Side D

| Reference Fuel | | Test Gear No. (12) | Throttle Position (16) | Man. Vac. Hg/psig (13) | Max. Knock Intensity (10) | | | (10) | Speed Range, RPM | | RPM of Max. of Intensit |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Acceleration | | | | | | |
| Series | Res. O.N. | | | | 1 | 2 | 3 | Final Rating | Knock In | Knock Out | |
| | | | | | | | | | | | |
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If part-throttle requirement is greater than four numbers below maximum-throttle requirement, enter F.
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COMMENTS