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1993 CRC DRIVEABILITY WORKSHOP

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

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1993 CRC DRIVEABILITY WORKSHOP

(CRC Project No. CM-118-93)

Prepared by the

CRC-Automotive Volatility Group

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Automotive Vehicle Fuel, Lubricant, and Equipment Research Committee

of the

Coordinating Research Council, Inc.

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I. INTRODUCTION

A driveability workshop was sponsored by the Coordinating Research Council, Inc. (CRC) October 4-8, 1993, at Michigan International Speedway near Jackson, Michigan. The workshop was conducted in response to interest expressed by members of the CRC Volatility Group. Twenty-one raters, technicians, and engineers attended the workshop. Attendees are listed in Appendix A. Training was accomplished through a handout manual, seminars using the manual, discussions, and actual track testing.

II. OBJECTIVE

There were two major objectives of the workshop. The first objective was to introduce the revised driveability procedure which had been developed for current-technology vehicles, and to make minor modifications to the procedure. The second objective was to train novice raters, improve the skills of trained raters, and provide uniform interpretation of definitions associated with the procedure.

Since the workshop was to be an educational experience rather than a source of driveability data, emphasis was placed upon exchange of information as opposed to data collection and analysis. The intent of the workshop was not to "rate the raters," but to reduce the laboratory-to-laboratory variations in the application of the Revised CRC Cold-Start and Warmup Driveability Procedure and the related terminology.

III. TEST VEHICLES

Eighteen vehicles were used for training and track testing. As indicated in Table 1, the vehicles were selected to provide a variation in manufacturers and engine sizes. Since one of the major objectives of the workshop was to validate the revised procedure which was developed for current-technology vehicles, most of the vehicles were port-fuel-injected (PFI). Most of the vehicles also had some minor inherent driveability malfunction. All but one of the vehicles had automatic transmissions; the manual-transmission vehicle was specifically arranged to provide an opportunity to try the revised procedure with a manual transmission.

Several of the vehicles were "rigged" to impair fully-warmed up driveability during one session of the workshop, to demonstrate types of malfunction and levels of severity. A few of the vehicles also had inherent fully-warmed up malfunctions which allowed them to be used in the same way. It was possible to use all these vehicles over and over again to allow rotation of all the training crews through the entire complement of malfunctioning vehicles with no change in malfunctions or severity. Some of the experienced trained raters were also able to simulate certain driveability problems for demonstration purposes. All of the eighteen vehicles were used for the crews to run mock tests to practice the cycle and evaluate each other's execution of the maneuvers in the procedure. These vehicles were used each morning to allow each participant the opportunity to actually conduct a cold-start and warmup test after an overnight soak.

Fourteen of the test vehicles were rented; four were test vehicles provided by one of the automobile manufacturers. An effort was made to obtain at least six pairs of vehicles to eliminate one of the variables during comparisons of various versions of the revised procedure.

IV. TEST FUEL

The fuel was targeted for especially poor performance during the cold-start and warmup testing. All vehicles were drained prior to the workshop and refueled with the test fuel. Inspection data furnished by the fuel supplier are given in Table 2.

V. TEST PROGRAM

The workshop was conducted October 4-8, 1993, at Michigan International Speedway near Jackson, Michigan. The workshop was planned to accommodate all levels of experience. Test crews were assigned with mixed levels of experience, with five experienced raters serving as trainers. Instructions were given both in driving/rating, and in being an observer/data recorder. In order to maximize the exchange of information, participants from difference companies were assigned to work together and were encouraged to discuss informally the different ways they conduct driveability ratings.

The first day and a half were devoted to procedure refinement and validation. The remaining time was used for training, discussion, practice of the test cycle on the test vehicles, demonstration of malfunctions and severity levels, and actual cold-start and warmup tests. Each participant had the opportunity to be a driver/rater, and each participant had the opportunity to be an observer.

It quickly became apparent that the expectations and needs of the participants varied somewhat. The least experienced of the group needed some basic instruction in performing the test, and recognizing the different types and severities of malfunction. The most experienced, however, wished to correlate their ratings, and discuss and possibly devise improvements to the rating and demerit scoring scheme. This disparity did cause some problems, particularly during the first one and a half days, when the new test procedure was being refined and validated.

The test procedure as modified at the workshop is provided in Appendix B.

Ambient temperatures during testing ranged from approximately 30°F to 60°F.

VI. DATA ANALYSIS

This report contains no analysis of the driveability data obtained during the workshop, because the data do not offer any information about the operation or success of the workshop. The workshop was designed to refine and validate the Revised CRC Cold-Start and Warmup Driveability Procedure and to improve the application of the revised procedure, and its success was the clarification of the technique to the participants and the increased consistency of driveability results expected in the future.

The individual data sheets obtained from the test runs were reviewed on-site shortly after their completion. Review of the first data sheets was used to determine which of several potential versions of the revised procedure should be pursued. Once a final determination was made about the procedure, the review was concerned with the proper completion of the form, and served as the basis for discussion. Trainers riding with the test crews were also able to offer input and advice following the completion of the practice tests.

VII. CONCLUSIONS

Both major objectives of the workshop were met. The revised driveability procedure was modified and validated, and included input from the trained raters. Other than limited in-house work with the revised procedure, this was the first chance to use the procedure under actual test conditions. Novice driver/raters were trained, and the skills of the experienced raters were sharpened. Although not every attendee left the workshop with the same caliber of expertise at performing as trained raters, all attendees left the workshop as experienced driver/raters, and developed a greater level of expertise through the classroom training and the on-track experience. Terminology associated with driveability rating was explained and discussed during the workshop, resulting in more uniform use of the terminology. Questions regarding the conduct and application of the procedure were discussed and answered. The consensus of the attendees was that the participants, including the experienced trained raters, left the workshop with a clearer understanding of the procedure and its intent, particularly since they were involved with the modifications made to the revised procedure.

The Michigan International Speedway (MIS) facility was ideal for an exercise of this type. Track, garage, and classroom facilities were all of a high standard and certainly helped the exercise to run smoothly and without incident or difficulty.

VIII. RECOMMENDATIONS FOR FUTURE RATING WORKSHOPS

The consensus of the participants was that this driveability workshop was of great benefit and should be held as often as practical. A duration of four days was successful. Mixing raters from different companies and with different experience levels for the track work was mostly a success. The workshop provided the ideal opportunity to conduct actual track work with the revised procedure using a variety of vehicles and a variety of raters, and many of the raters appreciated the chance to be included in determining the final procedure. Conducting the actual cold-start tests was of much assistance to the participants by allowing them to assimilate all they had learned for practical use.

For a future workshop, it may be worthwhile to consider alternative formats. This would depend on the needs of the participants. For less experienced raters, a workshop with a more instructional/teaching bias may be appropriate. A critical part of this would be the pre-workshop communications to the potential participants. This would ensure that their attitudes and expectations match the workshop demands and structure. A full discussion of such an idea is outside the scope of this report, but it is recommended that this is explored in the future when a need for training of raters arises. For the most experienced raters, a correlation exercise is more appropriate, where they can work together to agree on consistent interpretation of definitions and procedure. The most effective time to carry this out may be immediately prior to the start of a CRC driveability program.

TABLE 1

TEST VEHICLES

Make/Model	Color	Engine	Fuel System*	Trans-mission	Mileage
Buick Century	Blue	3.3/V6	PFI	Auto.	13,748
Buick Century	Red	3.3/V6	PFI	Auto.	6,316
Dodge Spirit	Maroon	2.5/I4	TBI	Auto.	11,719
Dodge Spirit	Red	2.5/I4	TBI	Auto.	10,896
Pontiac Grand Am	White	2.3/I4SOHC	PFI	Auto.	13,519
Pontiac Grand Am	Blue	2.3/I4SOHC	PFI	Auto.	8,179
Chevrolet Lumina	Red	3.1/V6	PFI	Auto.	13,063
Chevrolet Lumina	Blue	3.1/V6	PFI	Auto.	13,258
Ford Taurus	Red	3.8/V6	PFI	Auto.	13,934
Ford Taurus	Green	3.8/V6	PFI	Auto.	11,420
Dodge Dynasty	Black	3.0/V6	PFI	Auto.	22,440
Dodge Dynasty	Blue	3.0/V6	PFI	Auto.	14,506
Buick Regal	Red	3.1/V6	PFI	Auto.	15,526
Pontiac Bonneville	White	3.8/V6	PFI	Auto.	13,467
Ford Aerostar	Blue	3.8/V6	PFI	Auto.	Not Rec.
Lincoln Continental	Red	3.8/V6	PFI	Auto.	Not Rec.
Ford F-150 Pickup	Green	4.9/I6	PFI	Auto.	Not Rec.
Ford Ranger Pickup	Blue	4.0/V6	PFI	Manual	Not Rec.

* PFI = Port-Fuel-Injected
TBI = Throttle-Body-Injected

Table 2

Test Fuel Inspection Data

Gravity, API	52.1
Aromatics, vol. %	42.8
Olefins, vol. %	2
Saturates, vol. %	55.2
RVP, psi	6.31
Distillation, °F	
IBP	96
5% Evap.	127
10% Evap.	150
20% Evap.	184
30% Evap.	209
40% Evap.	228
50% Evap.	240
60% Evap.	252
70% Evap.	267
80% Evap.	287
90% Evap.	316
95% Evap.	336
End Point	414
% Recovery	98
% Residue	0.9
% Loss	1.1
RON	97.9
MON	88.6
(R+M)/2	93.3
Sulphur, ppm X Ray	30
Ethanol, vol.%	0
MTBE, vol.%	0

APPENDIX A

WORKSHOP PARTICIPANTS

Participants in the

1993 CRC Driveability Workshop

NAME	COMPANY
John Cooper, Leader	BP Oil Company
Les Bostick	Ashland Petroleum Company
Chris Bort	Carter Automotive Company
Mike Briggs	BP Oil Company
Dave Coleman	General Motors Corporation
Keith Corkwell	Texaco, Inc.
Jim Duffy	Exxon Research & Engineering Co.
Beth Evans	Coordinating Research Council, Inc.
Scott Groh	Exxon Research & Engineering Co.
Scott Jorgensen	General Motors Corporation
Ted Karmilovich	Exxon Research & Engineering Co.
Alan Orban	Carter Automotive Company
Doug Rathe	Shell Development Company
Bill Rozman	BP Oil Company
Greg Scherer	Southwest Research Institute
Steve Simms	Amoco Oil Company
Frank Stains	Southwest Research Institute
Jerry Stark	Phillips Petroleum Company
Matt Watkins	Mobil Research & Development Corp.
Ed Willis	Sun Refining & Marketing Company
Jim Wooten	Phillips Petroleum Company
Craig Carlson (part-time)	Ford Motor Company
Jim Uihlein (part-time)	BP Oil Company

APPENDIX B

REVISED CRC COLD-START AND WARMUP DRIVEABILITY PROCEDURE

REVISED CRC COLD-START AND WARMUP DRIVEABILITY PROCEDURE

A. Record all necessary test information at the top of the data sheet.

B. Turn key on for 2 seconds before cranking to pressurize fuel system. Make sure defrost is on and fan is in "low" position. Start engine per Owner's Manual Procedure. Record start time.

C. There may be a total of three starting attempts recorded. If the engine fails to start within 5 seconds on any of these attempts, stop cranking at 5 seconds and record "NS" (no start) in the appropriate starting time box on the data sheet. After the first and second unsuccessful attempts to start, turn the key to the "off" position before attempting to restart per the Owners Manual procedure. If the engine fails to start after 5 seconds during the third attempt, record an "NS" in the Restart2 box, then start the engine any way possible and proceed as quickly as possible to Step D without recording any further start times.

Once the engine starts on any of the first three attempts, idle in park for 5 seconds and record the idle quality. If the engine stalls during this 5-second idle, record a stall in the Idle Park "Stls" box, then restart per the above paragraph, subject to a combined maximum (in any order) of three no-starts and Idle Park stalls. After all the start-time boxes are filled, no further starts should be recorded.

D. Apply brakes (right foot), shift to "Drive" ("Overdrive" if available) for 5-second idle, and record idle quality. If engine stalls, restart immediately. Do not record restart time. Record number of stalls.

A maximum of three Idle Drive stalls contributes to demerits. If the engine stalls a fourth time, restart and proceed to the next maneuver as quickly as possible. It is important to complete the start-up procedure as quickly as possible to prevent undue warmup before the driving maneuvers and to maintain vehicle spacing on the test track.

E. After idling 5 seconds (Step D), make a brief 0-10 mph light-throttle acceleration. Light-throttle accelerations will be made at a constant throttle opening beginning at a predetermined manifold vacuum. This and all subsequent accelerations throughout the procedure should be "snap" maneuvers: the throttle should be depressed immediately to the position that achieves the pre-set manifold vacuum, rather than easing into the acceleration. Once the throttle is depressed, no adjustment should be made, even if the pre-set vacuum is not achieved. Use moderate braking to stop. Idle for approximately 3 seconds without rating it. Make a brief 0-15 mph light-throttle acceleration. Both accelerations together should be made within 0.1-mile. If both accelerations are completed before the 0.1-mile marker, cruise at 15 mph to the 0.1-mile marker. Use moderate braking to stop; idle for approximately 3 seconds without rating it.

F. Make a 0-20 mph wide-open-throttle (WOT) acceleration beginning at the 0.1-mile marker. Use moderate braking to achieve 10 mph and hold 10 mph until the 0.2-mile marker (approximately 5 seconds). Use moderate braking to stop; idle for approximately 3 seconds without rating it.

G. At the 0.2-mile marker, make a brief 0-10 mph light-throttle acceleration. Use moderate braking to stop. Idle for approximately 3 seconds without rating it. Make a brief 0-15 mph light-throttle acceleration. If accelerations are completed before the 0-3-mile marker, cruise at 10 mph to the 0.3-mile marker.

H. At the 0.3-mile marker, make a light-throttle acceleration from 10-20 mph. Use moderate braking to make a complete stop at the 0.4-mile marker in anticipation of the next maneuver. Idle for approximately 3 seconds at the 0.4-mile marker without rating the idle.

I. Make a 0-20 mph moderate acceleration beginning at the 0.4-mile marker.

J. At the 0.5-mile marker, brake moderately and pull to the right side of the roadway. Idle in "Drive" for 5 seconds and record idle quality. Slowly make a U-turn.

K. Repeat Steps E through J. At the 0.0-mile marker, brake moderately and slowly make a U-turn.

NOTE: Items L-N may be useful only at colder temperatures.

L. Make a crowd acceleration (constant predetermined vacuum) from 0-45 mph. Four-tenths of a mile is provided for this maneuver. Decelerate from 45 to 25 mph before the 0.4-mile marker.

M. At the 0.4-mile marker, make a 25-35 mph detent position acceleration.

N. At the 0.5-mile marker, brake moderately. Idle for 30 seconds in "Drive," recording idle quality after 5 seconds and after 30 seconds, and record any stalls that occur. This ends the driving schedule. Proceed to the staging area.

Definitions of light-throttle, detent, and WOT accelerations are attached. During the above maneuvers, observe and record the severity of any of the following malfunctions (see attached definitions):

1. Hesitation
2. Stumble
3. Surge
4. Stall
5. Backfire

It is possible that during a maneuver, more than one malfunction may occur. Record all deficiencies observed. Do not record the number of occurrences. If no malfunctions occur during a maneuver, draw a horizontal line through all boxes for that maneuver. Also, in recording subjective ratings (T, M, or H), be sure the entry is legible. At times, M and H recordings cannot be distinguished from each other.

Record maneuvering stalls on the data sheet in the appropriate column: accelerating or decelerating. If the vehicle should stall before completing the maneuver, record the stall and restart the car as quickly as possible. Bring the vehicle up to the intended final speed of the maneuver. Any additional stalls observed will not add to the demerit total for the maneuver, and it is important to maintain the driving schedule as closely as possible.

DEFINITIONS AND EXPLANATIONS

Test Run

Operation of a car throughout the prescribed sequence of operating conditions and/or maneuvers for a single test fuel.

Maneuver

A specified single vehicle operation or change of operating conditions (such as idle, acceleration, or cruise) that constitutes one segment of the drive-ability driving schedule.

Cruise

Operation at a prescribed constant vehicle speed with a fixed throttle position on a level road.

Wide Open Throttle (WOT) Acceleration

"Floorboard" acceleration through the gears from prescribed starting speed. Rate at which throttle is depressed is to be as fast as possible without producing tire squeal or appreciable slippage.

Part-Throttle (PT) Acceleration

An acceleration made at any defined throttle position, or consistent change in throttle position, less than WOT. Several PT accelerations are used. They are:

1. Light Throttle (Lt. Th) - All light-throttle accelerations are begun by opening the throttle to an initial manifold vacuum and maintaining *constant throttle position* throughout the remainder of the acceleration. The vacuum selected is the vacuum setting necessary to reach 25 mph in 9 seconds. The vacuum setting should be determined when the vehicle is cold. The vacuum setting is posted in each vehicle.

2. Moderate Throttle (Md. Th) - Moderate-throttle accelerations are begun by immediately depressing the throttle to the position that gives the pre-specified vacuum and maintaining a *constant throttle position* throughout the acceleration. The moderate-throttle vacuum setting is determined by taking the mean of the vacuum observed during WOT acceleration and the vacuum prescribed for light-throttle acceleration. This setting is to be posted in the vehicle.

3. Crowd - An acceleration made at a constant intake manifold vacuum. To maintain *constant vacuum*, the throttle-opening must be continually increased with increasing engine speed. Crowd accelerations are performed at the same vacuum prescribed for the light-throttle acceleration.

4. Detent - All detent accelerations are begun by opening the throttle to just above the downshift position as indicated by transmission shift characteristic curves. Manifold vacuum corresponding to this point at 25 mph is posted in each vehicle. *Constant throttle position* is maintained to 35 mph in this maneuver.

Malfunctions

1. Stall

Any occasion during a test when the engine stops with the ignition on. Three types of stall, indicated by location on the data sheet, are:

a. Stall; idle - Any stall experienced when the vehicle is not in motion, or when a maneuver is not being attempted.

b. Stall; maneuvering - Any stall which occurs during a prescribed maneuver or attempt to maneuver.

c. Stall; decelerating - Any stall which occurs while decelerating between maneuvers.

2. Idle Roughness

An evaluation of the idle quality or degree of smoothness while the engine is idling. Idle quality may be rated using any means available to the lay customer. The rating should be determined by the worst idle quality experienced during the idle period.

3. Backfire

An explosion in the induction or exhaust system.

4. Hesitation

A temporary lack of vehicle response to opening of the throttle.

5. Stumble

A short, sharp reduction in acceleration after the vehicle is in motion.

6. Surge

Cyclic power fluctuations.

Malfunction Severity Ratings

The number of stalls encountered during any maneuver are to be listed in the appropriate data sheet column. Each of the other malfunctions must be rated by severity and the letter designation entered on the data sheet. The following definitions of severity are to be applied in making such ratings.

1. Trace (T) - A level of malfunction severity that is just discernible to a test driver but not to most laymen.

2. Moderate (M) - A level of malfunction severity that is probably noticeable to the average laymen.

3. Heavy (H) - A level of malfunction severity that is pronounced and obvious to both test driver and layman.

4. Extreme (E) - A level of malfunction severity more severe than "Heavy" at which the lay driver would not have continued the maneuver, but taken some other action.

Enter a T, M, H, or E in the appropriate data block to indicate both the occurrence of the malfunction and its severity. More than one type of malfunction may be recorded on each line. If no malfunctions occur, enter a dash (-) to indicated that the maneuver was performed and operation was satisfactory during the maneuver.

DEMERIT CALCULATION SYSTEM

A numerical value for driveability during the CRC test is obtained by assigning demerits to operating malfunctions as shown. Depending upon the type of malfunction, demerits are assigned in various ways. Demerits for poor starting are obtained by subtracting one second from the measured starting time and multiplying by 4. The number of stalls which occur during idle as well as during driving maneuvers are counted separately and assigned demerits as shown. The multiplying x factors of 8 and 32 for idle and maneuvering stalls, respectively, account for the fact that stalls are very undesirable, especially during car maneuvers. A maximum of three total Idle Park stalls and No-Starts are permitted. A maximum of three Idle Drive stalls are permitted.

Other malfunctions, such as hesitation, stumble, surge, idle roughness, and backfire, are rated subjectively by the driver on a scale of trace, moderate, or heavy. For these malfunctions, a certain number of demerits is assigned to each of the subjective ratings. However, since all malfunctions are not of equal importance, the demerits are multiplied by the weighting factors shown to yield weighted demerits.

Finally, weighted demerits, demerits for stalls, and demerits for poor starting are summed to obtain total weighted demerits (TWD), which are used as an indication of driveability during the test. As driveability deteriorates, TWD increases.

A restriction is applied in the totaling of demerits to insure that a stall results in the highest possible number of demerits within a given maneuver. When more than one malfunction occurs during a maneuver, demerits are counted for only the malfunction which had the largest number of weighted demerits. Another restriction is that for each idle period, no more than 3 idle stalls are counted.

METHOD FOR CALCULATING TOTAL WEIGHTED DEMERITS (TWD)

Demerits for Poor Starting:

Demerits = (Starting Time(s) - 1) x 4
Demerits for No Start (NS) = 20

Demerits for Stalls:

Demerits = (No. of Idle Stalls) x 8 + (No. of Maneuvering or Decelerating Stalls) x 32

Demerits for Malfunctions Rated Subjectively:

Demerits for Subjective Ratings*

Trace	=	1
Moderate	=	2
Heavy	=	4
Extreme	=	To be Determined

Weighting Factors for Each Malfunction

Idle Roughness	=	1
Backfire, Stumble, Hesitation, Surge	=	6

Weighted Demerits = Demerits x Weighting Factor

Calculation:

Total Weighted Demerits = Weighted Demerits + Demerits for stalls + Demerits for Poor Starting

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NOTE: When more than one malfunction occurs in a driving maneuver, only the malfunction giving the highest weighted demerits is counted.

*Weighting Factors to be reviewed after 1994 Volatility Program

CRC Driveability Data Sheet

Run No. | Car | Fuel | Rater | Date | Time | Temperatures: Soak | Run | Odometer

Starting time, sec.: Initial | Restart1 | Restart2

Idle Park: Ruf Stls

Idle Drive: Ruf Stls

0.0 0-10 LT TH | **0-15 LT TH** | **0.1 0-20 WOT** | **0.2 0-10 LT TH** | **0-15 LT TH** | **0.3 10-20 LT TH** | **0.4 0-20 MD TH**

H S B
E T S K A D
S M G F C C

0.5 Idle Dr
Ruf Stls

0.5 0-10 LT TH | **0-15 LT TH** | **0.6 0-20 WOT** | **0.7 0-10 LT TH** | **0-15 LT TH** | **0.8 10-20 LT TH** | **0.9 0-20 MD TH**

H S B
E T S K A D
S M G F C C

0.0 Idle Dr
Ruf Stls

0.0 0-45 Crowd
H S B
E T S K A D
S M G F C C

0.4 25-35 Detent
H S B
E T S K A D
S M G F C C

0.5 Idle Dr
5 sec.
Ruf Stls

Idle Dr
30 sec.
Ruf Stls