CRC Report No. 645

2005 CRC HYBRID DRIVEABILITY WORKSHOP

September 2005

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(CRC Project No. AVFL-12c)

September 2005

CRC Performance Committee
and the
CRC Advanced Vehicle/Fuel/Lubricants
Committee
of the
Coordinating Research Council

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ABSTRACT

The Coordinating Research Council, Inc. (CRC) conducted a workshop during February 2005 as an initial investigation into the unique technology-independent issues associated with evaluating the cold-start and warm-up driveability of hybrid vehicles, regardless of their hardware or technology. The workshop was conducted as a joint endeavor by the CRC Performance Committee and the CRC Advanced Vehicle/Fuel/ Lubricants Committee. Ten vehicles (nine hybrid and one conventional) were tested with two fuels: one a marketplace fuel from California with a nominal Driveability Index (DI) of 1100, and one containing 10 volume percent ethanol with the DI targeted at 1300. Issues investigated during this workshop included instrumentation required for evaluating hybrids, a new defueling system, the effect of the preconditioning cycle on state-of-charge (SOC), and various maneuvers that might show promise for further investigation. A second workshop is planned for a later date when a broad spectrum of hybrid vehicles is available. This second workshop will then apply the results of this initial investigation to develop and validate a CRC hybrid test procedure using many different types of hardware and hybrid technologies with a wide range of DI fuels.

I. INTRODUCTION

In 2003, the Advanced Vehicle/Fuel/Lubricants (AVFL) Committee of the Coordinating Research Council, Inc. (CRC) asked the Volatility Group of the CRC Performance Committee to evaluate four hybrid vehicles as they conducted a cold-start and warm-up driveability program on the effect of Driveability Index (DI) and ethanol(1). An analysis of the objective and subjective data suggests that hybrids can be evaluated using the existing E-28-94 cycle, but that the results will not fully portray the fuel response due to differences between the conventional and hybrid powertrains. During the field testing, members of the Volatility Group became quite interested in the hybrids and indicated support for further work.

Not only was the possibility of a modified test indicated, it became clear that the basic methods used to prepare the vehicles for testing might not work for hybrids; furthermore, the matter of establishing a standard initial battery state-of-charge (SOC) was entirely new to driveability testing.

Hybrids are a growing market, with several new models having entered the commercial arena in 2004, and more set to enter the market in the next several years. It will be important to characterize the fuel response of these vehicles as their presence in the overall US fleet grows. Thus, the AVFL and Performance Committees are working together to develop the proper methods to prepare and test these vehicles.

The workshop reported on in this document was conducted in Yakima, Washington, January 31 – February 18, 2005. The intent of this workshop was an initial investigation of the issues associated with evaluating the driveability of hybrids, regardless of their hardware or technology. A second workshop is planned for a later date when a broad spectrum of hybrid vehicles is available. This second workshop will then apply the results of this initial investigation. Deliverables from the second workshop would include developing and validating a CRC hybrid test procedure using many different types of hardware and hybrid technologies. These vehicles would be tested using a wide range of DI fuels.

Participants in the current workshop are shown in Appendix A, and Appendix B outlines the program as approved by the CRC AVFL and Performance Committees.

II. CONCLUSIONS

- Using a voltmeter rather than a vacuum gauge to determine throttle position was extremely successful, and is recommended for all future testing, whether hybrid or conventional vehicles are used.

- During the workshop, at least two items were identified for which there is no rating scale available: sluggishness or sustained lack of power; and routine automatic shutdowns versus stalls.

- The current 3-second idle between maneuvers to allow the vehicle to stabilize after the preceding maneuver (and not be influenced by the preceding maneuver) should be addressed to determine if it allows enough time for stabilization and engine engagement and disengagement between maneuvers. Because the engine engagement after an automatic shutdown is handled differently in different vehicles, a uniform, generic stabilization period should be investigated.

- The new defueling system used during this workshop is recommended for use in all future testing, whether hybrid or conventional vehicles are used. The defueling system is faster, safer, more efficient, works with variable speed fuel pumps, and minimizes the chance of damage to the fuel pump or the electronic control module. The new defueling system allowed the hybrid and conventional vehicles to be drained and flushed in an acceptable length of time that would not impede testing.

- The effect of the battery state-of-charge (SOC) attained during the warm-up cycle used to precondition the vehicle for the next day's testing was found to be minimal at best. In-depth investigation during the workshop showed that there was no repeatable effect of SOC. It was determined on-site that with these test vehicles, the preconditioning cycle which had been traditionally used with conventional vehicles was effective at letting each vehicle consistently and repeatably find its own natural SOC each day. The goal of investigating the preconditioning cycle was not to find a preconditioning cycle for each type of hybrid design or each model which would be technology-dependent, but to find a preconditioning cycle that had the same general effectiveness across all the vehicles tested.

- The test techniques used during the second week of the workshop (February 14th through 18th) showed promise of fuel sensitivity using this fleet of vehicles, and may be a suitable starting point for further investigation.

III. TEST VEHICLES

Ten vehicles comprised the test fleet as shown in Table 1, nine of which were hybrid vehicles, and one of which was a conventional (non-hybrid) vehicle. Of the nine hybrid vehicles, six were Honda Civics (four 2003 and two 2004), one was a 2004 Toyota Prius, one was a 2005 Chevrolet pick-up truck, and one was a 2005 Ford Escape. Two of the hybrid Civics were SULEV (super ultra low emissions vehicle) technology. The remainder of the hybrid Honda Civics were ULEV (ultra low emissions vehicle) technology. The Ford Escape was also SULEV technology. The Toyota Prius was PZEV (partial zero emissions vehicle) technology.

The conventional vehicle was a 2001 Honda Civic. The original purpose of the conventional vehicle was to give a baseline comparison for the continuously variable transmission (CVT) used in many of the hybrids. By helping the trained raters become familiar with the operation of the CVT in a conventional vehicle, it was anticipated that this would reduce some of the confounding of the CVT and hybrid vehicle operation. The conventional Civic was equipped with a lean-burn engine calibration, and had a larger engine than the hybrid Civics. It became immediately apparent that the conventional vehicle could be used to confirm results that might be expected in a conventional vehicle fleet. For instance, during testing with the traditional Cold-Start and Warm-up Driveability Procedure, the hybrids were not showing fuel effects, but the conventional car was. It was thus possible to use the conventional vehicle as a "reality-check."

IV. TEST FUELS

Two fuels were used in the workshop. One fuel was a marketplace fuel from California with a nominal DI of 1100 (actual DI was 1065.65). Although this fuel was intended to be a hydrocarbon-only fuel, inspections showed it to contain 1.8 volume percent MTBE, most likely due to contamination during shipping. The second fuel contained 10 volume percent ethanol with the DI targeted at 1300 (actual DI was 1306.2). This fuel was specially blended to meet the test fuel specification limits shown in Appendix B. The fuels were meant to allow simple observation of a range in fuel effects without departing too radically from the fuels actually experienced on a very occasional basis. The fuel inspection data are shown in Table 2.

The DI was calculated for each of the test fuels using the equation:

$$DI = 1.5*T_{10} + 3.0*T_{50} + 1.0*T_{90}$$

Where T_{10} is the 10% evaporated point, T_{50} is the 50% evaporated point, and T_{90} is the 90% evaporated point from an ASTM D 86 distillation.

V. TEST TOOLS

Vacuum gauges (which have traditionally been used for driveability testing) are virtually useless with hybrid vehicles because of the engagement and disengagement of the engine. The vehicles were thus instrumented with leads for connection of a voltmeter to determine throttle position. Use of the voltmeter was extremely successful, and is recommended for further testing, whether hybrid or conventional vehicles are used.

Vehicles were not necessarily instrumented in the same manner to obtain voltage readings. The Honda Civics were cable-driven, so that voltage on the throttle valve was read, but it was mechanically actuated. The Toyota Prius, the Ford Escape, and the GM truck all incorporated drive-by-wire technology similar to that used in conventional (non-hybrid) vehicles. Voltage readings were obtained from the accelerator pedal, except for one model on which voltage was initially obtained from the throttle valve, not on the pedal. The voltmeter leads were rewired during the workshop to pick up the voltage from the pedal. It was noticed that it takes more pedal movement to obtain a pre-set acceleration rate when the vehicle is cold than when it is warmed-up. It was also noticed that the voltage/pedal interaction changes when the vehicle goes into the closed-loop mode. These findings are consistent with what is experienced with vacuum in conventional vehicles at low temperatures.

The same traditional definition of light throttle was used: 0 – 25 mph in 9 seconds. Moderate throttle was defined as: (T_{WOT} + 9 seconds) divided by 2, where T_{WOT} is the time from 0 – 25 mph at wide-open-throttle. Heavy (50 percent and 70 percent) throttle was calculated using a worksheet provided by BP Global Fuels Technology which determines throttle position percentage.

The auto manufacturers advised that throttle percentages are not linear, and this was proven in attempts to determine throttle percentages. Throttle percentages were checked on one run using a generic scan tool and it was determined that moderate-throttle settings were approximately one-third throttle, and heavy-throttle settings were either 50 percent or 70 percent throttle. The auto manufacturers had advised that very heavy throttle (e.g., 70 percent) would react similarly to wide-open-throttle maneuvers, and this was confirmed during the workshop. This is why the final sequence of maneuvers did not include a wide-open-throttle maneuver. The workshop participants all agreed that a consumer is more apt to use a heavy-throttle maneuver than a wide-open-throttle maneuver.

VI. BATTERY PACK TEMPERATURES

The auto manufacturers suggested recording battery pack temperatures during the testing and immediately after testing. The workshop participants were able to successfully use nine thermocouple recorders for the nine hybrid vehicles. It must be noted, however, that the recorders were not calibrated and should not be construed as recording accurate temperatures. Recorders were kept with the same vehicle, so comparisons of temperatures from day-to-day for each vehicle could be made. The recorded temperatures are presented in Appendix C.

Thermocouples were placed on the battery packs. Temperatures were recorded most days for as long as was logistically practical. On several days, the thermocouple recorders were allowed to run until the battery pack temperatures appeared stabilized. On days when it was necessary to defuel and flush the vehicles, the thermocouple recorders were turned off shortly (approximately one-half hour) after testing to allow the fueling personnel to work with the vehicles. The thermocouple recorders were set to record temperatures every five minutes.

During the second week of the workshop, a scan tool was available for use at the workshop for one of the vehicles, and it was possible to read the interior temperatures of the battery pack for that vehicle. The interior temperatures read by the scan tool were consistently higher than the battery pack skin temperatures recorded. On another of the vehicles, a second thermocouple was placed in the intake air of the battery pack. This thermocouple showed different temperatures than the battery pack skin. It was not possible to instrument the battery packs on-site to read internal temperatures, and the one Original Equipment Manufacturer (OEM) scan tool was the only scan tool available that was equipped to read battery temperatures. If battery pack temperatures are to be recorded in the future, battery packs will need to be instrumented by the manufacturer for internal thermocouples, or OEM scan tools will be necessary. Knowing this in advance will make the future test development work more productive and effective.

VII. TEST PROGRAM

Set-up week for the workshop, including two days of practice tests, was the week of January 31, 2005. Actual testing was done February 7 – 18, 2005. Results of all tests, including the practice runs, are given in Appendix D.

Practice tests were conducted on February 3rd and 4th using the traditional CRC Cold-Start and Warm-up Driveability Procedure detailed in Appendix E. Tank fuel which was in the vehicles when they were received was used on February 3rd, and the 1300 DI test fuel was used on February 4th.

Since this was an investigative workshop rather than a formal data-gathering driveability program, no effort was made to balance testing between the two fuels. The 1300 DI fuel was used in exploratory efforts to determine whether or not the fleet showed malfunctions. If relatively minimal malfunctions were encountered with the 1300 DI fuel, there was no reason to test the 1100 DI fuel. The 1100 DI fuel was intended and was used to confirm fuel sensitivity of the fleet.

A. Investigation of State-of-Charge (SOC)

The warm-up procedure used on February 2nd to precondition the vehicles for the next day's testing on the 3rd was the traditional warm-up procedure used on the track in the past. Speeds of 15, 25, 35, 45, and 55 mph were held for specified mileages for a total of 10.2 miles. The only difference was that the warm-up procedure started at 15 mph and finished at 55 mph during this workshop, rather than starting at 55 mph and finishing at 15 mph as had been done in the past.

It was found that the warm-up procedure described above caused the SOC to be above half-charge for the overnight soak and testing the next day. The workshop participants drove the vehicles on a public-road warm-up route that had been used in the past. The purpose of this on-road driving was to determine what the SOC would be with a typical consumer, driving in a typical manner, in real-world conditions. It was determined that the vehicles found their own SOC somewhere in mid-range.

In an attempt to investigate lowering the SOC when preconditioning on February 3rd, the last two lengths of the track were run at wide-open-throttle with minimal braking. This could potentially pose an unsafe condition, however, so an alternate method of decreasing the SOC was tried.

As an alternative method of decreasing the SOC, the warm-up done on February 6th for testing on the 7th used "bunny hops" for the last length of the track. On the last length, three or four 0 – 55 mph wide-open-throttle maneuvers with moderate to hard braking were used to lower the SOC. Because the auto manufacturers advised that the hybrids would find their own natural SOC and automatically attempt to be at that SOC, it was decided to investigate the effect of SOC on testing.

Cold-start and warm-up tests were conducted with the fleet on February 7th, 8th, 9th, and 10th. For testing on the 7th with 1300 DI fuel, the vehicles were preconditioned using "bunny hops." Testing on the 8th was done with 1300 DI fuel with no "bunny hops" used in the preconditioning cycle. Testing on the 9th was done with 1100 DI test fuel with "bunny hops" used to precondition the vehicles, and testing on the 10th was done with 1100 DI test fuel with no "bunny hops."

Those four days of testing showed that there was not a repeatable effect of SOC (fleet average total weighted demerits of 34, 44, 29, and 29, respectively), so the warm-up cycles done subsequent to testing on the 10th were all done in the traditional manner. Warm-up cycles from February 10th through February 17th were done as follows: 15 mph from the staging area to the quarter-mile speed sign; 25 mph for the remainder of that length of the track; 35 mph for one length of the track; 45 mph for one length of the track; and 55 mph for the remainder (11 lengths) of the 10.2 miles. One length of the track is 0.728 miles, and the entire preconditioning cycle is 14 lengths. Moderate-throttle accelerations were used to attain the prescribed speeds.

Subsequent to the investigation of SOC, one of the auto manufacturers suggested that the easiest way to discharge the hybrid battery pack is a wide-open-throttle maneuver followed by braking in neutral gear. It was also learned that the battery-indicators in the vehicles are usually not truly accurate; often, only part of the range is shown on the indicator (i.e., the driver would not see full charge or full discharge on the indicator on the dashboard). Unnatural discharge is not desirable, since the intent of the test procedure is not to mimic situations that vehicles are very unlikely to experience. The final warm-up design should put the batteries at the low end of their SOC normal operating range. The goal of this investigation of SOC was not to find a preconditioning cycle for each type of hybrid design or each model which would be technology-dependent, but to find a preconditioning cycle that had the same general effectiveness across all the vehicles tested. The traditional warm-up cycle described in the preceding paragraph was effective at letting each vehicle find its own natural SOC repeatably each day.

It should be noted that what was observed with the preconditioning cycles is indicative of what can happen, but it is too early in the development of hybrid systems and the fleet was too small to say with certainty that the preconditioning cycle settled on for this workshop incorporates the best maneuvers to achieve a desired SOC. It will serve as a good starting point in coming years when an official CRC preconditioning and test cycle is developed using a more diverse and mature fleet.

B. Investigation of Test Maneuvers

Meetings of the workshop participants were held at the end of testing each day to discuss what had worked that day and what had not. The same total weighted demerit (TWD) scale used with the CRC Cold-Start and Warm-up Driveability Procedure was used to calculate the demerits of the vehicles each day. This scale was arbitrarily chosen on-site only because this scale is a familiar one that has been traditionally used in CRC driveability programs. It is a tool used to evaluate the hybrids and should not be construed as an evaluation itself. The moderate-throttle weightings were used for the 50-percent and 70-percent throttle maneuvers. Data sheets for each of the test procedure variations used are given in Appendix F. An auxiliary worksheet which was used for the first week or so of testing is also located in Appendix F. This auxiliary worksheet was used to record SOC, rates of charge and assist, and voltages in an effort to understand hybrid operation.

Since it was apparent that the hybrid vehicles were not responding to the traditional CRC Cold-Start and Warm-up Driveability Procedure, some variations were tried beginning with testing on February 11th. The crowd and detent maneuvers were eliminated, since by definition, they could not be used with hybrid vehicles. As mentioned previously, vacuum gauges are virtually useless with hybrids, and the crowd maneuver is defined by a constant vacuum setting. Many hybrid vehicles have CVT transmissions which precludes being able to conduct a 25 – 35 mph detent maneuver.

Testing on the 11th used 1300 DI fuel and replaced the crowd and detent maneuvers with a third replicate of the first and second set of maneuvers in the Cold-Start and Warm-up Driveability Procedure. Idles between the sets of maneuvers had traditionally been 5 seconds long; they were changed to 30 seconds with an idle rating at 5 seconds and 30 seconds. The idles were lengthened to simulate traffic lights and heavy stop-and-go traffic for greater consumer relevancy. The fleet average TWD was 62.

Since the hybrid vehicles still did not appear to be responsive to that test technique, another variation was used on the 12th with 1300 DI fuel. This test technique used 0 – 20 mph moderate-throttle maneuvers followed by 0 – 15 mph light-throttle maneuvers. The moderate-throttle and light-throttle maneuvers were interspersed alternately with a wide-open-throttle maneuver done for the last maneuver for each set. This test retained the 30-second idles between sets. Four sets were done, with the HVAC off for the fourth set. There were a few vehicles which showed some response to this test technique, but the fleet as a whole was not responsive (fleet average TWD of 99).

On the 13th, the test technique was changed to two moderate-throttle maneuvers for one-tenth mile, followed by two light-throttle maneuvers for one-tenth mile. This was repeated once, followed by a 0 – 30 mph wide-open-throttle maneuver done as the last one-tenth-mile maneuver for each set (each set is 0.5 mile). The 30-second idles were retained between sets, with two sets being done with the HVAC on, followed by the HVAC off for the third set. Again, several vehicles were responsive to this test technique, but the fleet as a whole was not (fleet average TWD of 88).

Testing during the second week of the workshop concentrated on a different test cycle. The first maneuver was 50-percent throttle from 0 – 20 mph, immediately followed by a 0 – 15 mph light-throttle maneuver. At the 0.1 mile marker, another 0 – 15 mph light-throttle maneuver was done, immediately followed by 0 – 20 mph moderate-throttle maneuver. The 0.2 and 0.3 mile markers repeated the 0.1 mile marker maneuvers. The 0.4 mile maneuver was a 0 – 20 mph 70-percent throttle maneuver. The 30-second idles were retained between sets. On the 14th, four sets of these maneuvers were used with 1300 DI fuel. The first set had the HVAC on, the second set had the HVAC off, the third set had the HVAC on, and the fourth set had the HVAC off. The HVAC was turned on or off immediately after the 30-second idle between sets; the engine was allowed to stabilize for 15 seconds after turning the HVAC on or off. This 15-second stabilization period also allowed time for engine engagement or disengagement during the automatic shutdown. Overall, the responsiveness of the fleet to this test technique was promising (fleet average TWD of 132), so this test technique was repeated on the 15th. The repeatability of the fleet as a whole was encouraging, with only two of the vehicles failing to repeat the results of the previous day. The fleet average TWD on the 15th was 125, as compared with 132 the previous day. To try to determine whether the sequence of the HVAC's being on or off had an impact, the same sequence of maneuvers was used on the 16th with the 1300 DI fuel except the first set had the HVAC off, the second set had the HVAC on, the third set had the HVAC off, and the fourth set had the HVAC on. There did not appear to be any discernible significant impact of the HVAC activity, with a fleet average TWD on the 16th of 130.

To verify whether the hybrids were fuel-sensitive with these test techniques and sequences of maneuvers, the test technique used on the 16th was repeated on the 17th with 1100 DI fuel. The test technique used on the 14th and 15th was repeated on the 18th with 1100 DI fuel. The fuel sensitivity of this fleet of vehicles using these test techniques was promising, although the length of the workshop did not allow for thorough investigation. The fleet average TWD on the 16th (1300 DI fuel) was 130, compared with 86 on the 17th (1100 DI fuel). The fleet average TWDs on the 14th and 15th were 132 and 125, respectively (1300 DI fuel), compared with 107 on the 18th (1100 DI fuel).

The raters evaluated all formal idles during each test for which there was a place on the data sheet to record malfunctions. Stabilization periods after switching the HVAC on or off were not evaluated. If the engine disengaged (automatic shutdown) during an idle, the idle was evaluated only during the time the engine was engaged, and a note was recorded on the data sheet that an automatic shutdown had occurred.

Again, it should be noted that what was observed with the series of test maneuvers used is indicative of what can happen, but it is too early in the development of hybrid systems and the fleet was too small to say with certainty that the maneuvers investigated during this workshop should be used. Rather, this experience should be used to guide future test development work.

C. Test Parameters

Every effort was made to keep the ambient test temperatures stable during each day as well as between test days. Testing was targeted to be conducted between 35° and 40°F. It should be noted that different ambient temperatures might affect parameters such as the air-conditioning cycling on or off. Overnight soak temperatures were relatively stable as well, ranging from 23°F to 30°F, with the average soak temperature approximately 27°F.

Rater-vehicle combinations were random until testing on the 15th. Because it was desirable to keep the same rater with the same vehicle once a promising sequence of maneuvers was identified, the rater-vehicle combinations were kept the same as they were on the 14th. In retrospect, it would have been good if a single rater had not tested all Honda Civics; however, there was no way to know on the 14th that this particular sequence of maneuvers would have provoked keeping the same rater with the same vehicle. If the workshop had lasted another few days, it would have been possible to investigate that rater-vehicle combination, but this item will need to be investigated more thoroughly at the next workshop. The next workshop should also include a wider variety of vehicles and more iterations of each model.

VIII. ITEMS REQUIRING FURTHER STUDY

At least two items were identified during the workshop for which there is no rating scale available. Sluggishness and lack of power were often noted. Sluggishness can be defined as a sustained lack of power (though with continual forward motion) throughout the maneuver, unlike hesitation and stumble both of which exhibit lack of power during throttle movement that eventually recovers during the maneuver (often suddenly), and surge which has a cyclic or rhythmic response to throttle movement. There was also some question whether a maneuver would result in a stall or a routine automatic shutdown (where the engine shuts itself down and operates on battery power only). There were several instances where the vehicle would be running rough and "sputter" before an automatic shutdown. The workshop participants were able to identify various characteristics of the manufacturers regarding automatic shutdowns and battery pack operation.

The current 3-second idle between maneuvers to allow the vehicle to stabilize after the preceding maneuver should be addressed to determine if it allows enough time for stabilization and engine engagement and disengagement between maneuvers. The 3-second stabilization between maneuvers has traditionally been used with conventional vehicles so that the beginning of one maneuver is not heavily influenced by the preceding maneuver. This short stabilization period has an added function with hybrid vehicles, in that with some vehicles, the engine engagement after an automatic shutdown can influence the following maneuver. Because the engine engagement after an automatic shutdown is handled differently in different vehicles, a uniform, generic stabilization period should be investigated. In addition, the final procedure should remind trained raters not to use two-foot braking, since this can affect the engine engagement after an automatic shutdown.

Some of the makes and models inherently have what the CRC rating system terms "malfunctions" because of the way the engine and battery operate during and between maneuvers. For example, an engine that has an automatic shutdown between maneuvers and then engages after the acceleration has been initiated would have a built-in hesitation or stumble. If the rater calls out each malfunction without trying to sort out whether it is mechanical or fuel-related, the vehicle will sort the fuels, albeit at a higher demerit level. It would be expected that a mechanical malfunction would show up consistently, thereby deterministically increasing the level of demerits recorded above that due simply to fuel-related malfunctions. This is no different than what has transpired with conventional vehicles in the past; many times, specific vehicles will have higher demerit scores than the remainder of the fleet, but will sort the fuels nonetheless.

An item needing further thought is how to deal with automatic shutdowns versus vehicles that continue engine operation and thus have an idle rating. The vehicles that have an idle that can be rated obviously can be penalized for that idle; however, a vehicle that has had an automatic shutdown risks roughness or heavy weight malfunctions in the restart process. This issue should be addressed in a way that is accurate and simple, and that is generic across all hybrid strategies. The simplest and most accurate solution may be to rate idles as they happen, regardless of whether the vehicle has had an automatic shutdown or not.

It was found that having the air conditioner on and switched to the defrost/foot mode, with the temperature at maximum cold (an equivalent of 60°F), and with the fan set at low to moderate fan speed would keep the engine/battery interaction at their most consistent operation (least variation from test-to-test under the same conditions).

The workshop participants all agreed that it would be beneficial to test both hybrids and conventional (including CVT and non-CVT automatic transmission) vehicles using the same test technique. The sequence of maneuvers used during the second week of the workshop was encouraging for use with conventional vehicles as well as hybrids. This would allow hybrid and conventional vehicles to be tested within the same fleet, and would provide a "reality check" or internal standard.

IX. DEFUELING PROCEDURE

A defueling system developed and donated by one of the workshop participants was used during the workshop. The defueling system incorporates a pressure gauge, a sight glass, and a pressure regulating valve. This system assists with draining vehicles equipped with variable speed fuel pumps. It becomes evident when the pump has run dry. In the past, there was a danger of potential damage to the pump by continuing to run it after it had run dry. This new system also eliminates the need to “jumper wire” the fuel pump so that it will run on-demand. The new system is also safer, since it is a totally closed system.

The new defueling system allowed the hybrid and conventional vehicles to be drained and flushed in an acceptable length of time that did not impede test timing. Past experience had shown the hybrid vehicles to defuel slowly enough to be problematic, so this was an important advancement.

The only problem still to be addressed is when the vehicle has an automatic shutdown during defueling. When that occurred at this workshop, someone would either sit in the vehicle and physically accelerate it, or a prop would be used on the accelerator pedal.

The defueling procedure is described in detail in Appendix G. At the completion of testing, if a different fuel was to be used for the next day, the vehicles were dropped off at the defueling area. The gas cap was removed, and the remaining test fuel was drained from the vehicle through the fuel rail system. The vehicle fuel system was then flushed using the procedure developed for the CRC 2001 Volatility Program(2). The vehicles were flushed and fueled with the next day’s test fuel.

An evaluation of the fuel flushing and refueling procedure was conducted during the 2001 and 2003 CRC Volatility Programs(1,2). In those programs, the vehicles were sampled after completion of testing with a hydrocarbon-only fuel, which was immediately preceded with a 10 volume percent ethanol fuel. Review of the flushing data has indicated that with few exceptions, the ethanol level was less than 0.5 volume percent ethanol carryover. A carryover of 0.5 volume percent ethanol corresponds to about 5 volume percent dilution of the test fuel with the previous test fuel.

X. REFERENCES

1) Coordinating Research Council, Inc., 2003 CRC Intermediate-Temperature Volatility Program, CRC Report No. 638, February 2004.

2) Coordinating Research Council, Inc., 2001 CRC Hot-Fuel-Handling Program, CRC Report No. 629, June 2002.

Table 1

2005 CRC Hybrid Driveability Workshop – Test Vehicles

Year	Make/Model	Displacement, L	VIN
2001	Honda Civic	1.7	1HGEM22761L031920
2003	Honda Civic	1.3	JHMES966X3S013328
2003	Honda Civic	1.3	JHMES96693S012316
2003	Honda Civic	1.3	JHMES96663S012998
2003	Honda Civic	1.3	JHMES96663S013004
2004	Honda Civic	1.3	JHMES96624S002020
2004	Honda Civic	1.3	JHMES96624S008030
2004	Toyota Prius	1.5	JTDKB20U440011848
2005	Chevrolet Pick-Up Truck	5.3	1GCEC19T05Z137877
2005	Ford Escape	2.3	1FMCU95H05KC07550

Table 2

2005 CRC Hybrid Driveability Workshop Test Fuel Inspections

Inspection	Units	1300 DI	1100 DI
D 86 Distillation			
IBP	°F	86.6	83.1
5% Evap	°F	102.2	100.5
10% Evap	°F	114.3	110.3
20% Evap	°F	133.9	128.6
30% Evap	°F	151.6	150.2
40% Evap	°F	163.5	174.2
50% Evap	°F	257.7	198.8
60% Evap	°F	293.0	223.1
70% Evap	°F	320.2	245.1
80% Evap	°F	341.2	269.4
90% Evap	°F	361.7	303.8
95% Evap	°F	381.9	333.5
EPT	°F	421.0	388.4
Recovered	Vol %	96.7	97.6
Loss	Vol %	2.0	1.2
Residue	Vol %	1.2	1.2
DI		1306.2	1065.65
DVPE	psi	11.5	12.31
Gravity	°API	53.7	59.9
Specific Gravity		0.7640	0.7393
DHA			
Aromatics	Vol %	35.4	19.7
Olefins	Vol %	5.3	10.7
Saturates	Vol %	49.7	67.7
Ethanol	Vol %	9.6	0.0
MTBE	Vol %	0.0	1.9
Benzene	Vol %	0.419	0.4
D 4815			
Ethanol	Vol %	9.6	<0.1
MTBE	Vol %	<0.1	1.8

APPENDIX A

ON-SITE PARTICIPANTS IN THE

2005 CRC HYBRID DRIVEABILITY WORKSHOP

ON-SITE PARTICIPANTS IN THE 2005 CRC HYBRID DRIVEABILITY WORKSHOP

Name	Affiliation
Harold "Archie" Archibald	Consultant
Robert Becker	Exxon Mobil
Greg Browne	Shell Global Solutions (UK)
Beth Evans	Evans Research Consultants
Jeff Jetter	Honda R&D Americas, Inc.
Jimmy Pitta	Chevron Oronite Company
Richard Riley	ConocoPhillips
Hideharu Takemoto	Honda R&D Americas, Inc.
Matthew Thornton	National Renewable Energy Lab
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APPENDIX B

PROGRAM PROPOSAL FOR THE 2005 CRC HYBRID DRIVEABILITY WORKSHOP

2005 CRC HYBRID VEHICLE COLD-START AND WARM-UP DRIVEABILITY WORKSHOP

Objective

Conduct an initial investigation into the unique technology-independent issues associated with evaluating the cold-start and warm-up driveability of hybrid vehicles that are not dependent on the manufacturer, control logic, or the level of hybridization.

Deliverables

An appraisal of those parts in the existing E-21-94 cycle and warm-up schedule that are inappropriate for hybrids.

An appraisal of new or unique aspects of hybrid function that interact with fuel, and could require new maneuvers to address.

A defueling and refueling process for hybrids.

A warm-up procedure for hybrids that will contribute to assessment of fuel interactions in hybrids by achieving an appropriate and reproducible state-of-charge (SOC).

Initial modification concepts for a cold-start and driveaway test based on E-21-94 specifically tailored to effectively determine the cold-start and driveaway driveability of hybrids.

Introduction

In 2003, the CRC Advanced Vehicle/Fuel/Lubricants (AVFL) Committee asked the Volatility Group of the CRC Performance Committee to evaluate four hybrid vehicles as they conducted a cold-start and warm-up driveability program on the effect of Driveability Index (DI) and ethanol. The analysis of the objective and subjective data suggests that hybrids can be evaluated using the existing E-21-94 cycle, but that the results will not fully portray the fuel response due to differences between the conventional and hybrid powertrains. During the field testing, members of the Volatility Group became quite interested in the hybrids and indicated support for further work.

Not only was the possibility of a modified test indicated, it became clear that the basic methods used to prepare the vehicles for testing may not work for hybrids; furthermore, the matter of establishing a standard initial battery SOC is entirely new to driveability testing.

Hybrids are a growing market, with several new models set to enter the commercial arena in 2004. It will be important to correctly characterize the fuel response of these vehicles as their presence in the overall US fleet grows. Thus, the AVFL and Performance Committees will work together again to develop the proper methods to prepare and test these vehicles through a workshop devoted solely to this goal. This workshop will be an initial investigation of the issues associated with evaluating the driveability of hybrids, regardless of their hardware or technology. A second workshop is tentatively planned for a later date when a broad spectrum of hybrid vehicles is available. This second workshop will then apply the results of this initial investigation to develop and validate a CRC hybrid test procedure using many different types of hardware and hybrid technologies with a wide range of DI fuels.

Test Program

Determine the maneuvers that are problematic to evaluate fuel effects on hybrid vehicles.

Identify new maneuvers that may be needed to fully test hybrids.

Evaluate the appropriateness of the currently defined malfunctions (e.g., hesitation, idle ratings).

Determine a rapid and effective defuel and refuel process.

Determine a method of reproducibly achieving a level of SOC that is appropriate to the individual vehicle in order to fully evaluate fuel effects and which also reflects a state that consumers might encounter.

Test Fuels

Two fuels will be used in the workshop. One fuel will be hydrocarbon-only and designed to have a DI at or below 1100, with distillation properties typical of marketplace pump gasoline. The second fuel will contain 10 volume percent ethanol with the DI targeted at 1300. The fuels are meant to allow simple observation of fuel effects without departing too radically from the fuels actually experienced on a very occasional basis. Fuels will be blended with refinery streams and should not have unusually shaped D 86 distillation curves. All appropriate carbon numbers should be represented in both fuels. The T50 and T90 specifications for the 1300 DI fuel should be tightly controlled and adhered to. The T10 for the 1300 DI fuel can be allowed to float; however, every effort should be made for the fuel to be as close to 1300 DI as possible. The fuel specifications are outlined in Table B-1.

Test Vehicles

Ten to twenty hybrid vehicles are proposed for the test fleet. Because the vehicles can make only one run per day, there is a need for several editions of each one to: a) allow for testing various theories on the same day, and b) evaluate the variance in the test process.

Innovative sourcing will be required as these vehicles are not commonly available in rental fleets. To make the test developed in this workshop as representative as possible, beta vehicles and validation vehicles should be obtained for models not yet released. Even the commercially available vehicles will need to be sourced from the test fleets of participating members. Collecting the vehicles all in the test site at the same time will take significant coordination, corporate will, and managerial skill. This task must be started as soon as the site is chosen.

Test Procedure

The fuels will be tested using the CRC Cold-Start and Warm-up Driveability Test Procedure (E-21-94) as a point of departure. Maneuvers that do not fully capture fuel response of hybrid vehicles will be identified, and suggestions regarding those maneuvers will be made. Placement of individual maneuvers in the overall cycle will also be evaluated as to whether they influence battery operation.

In parallel, a new defuel/refuel process will be developed, and, additionally, the vehicle preparation process will be evaluated. These processes need to at least integrate well with the existing conventional preparation processes. It will be desirable to retain as much of the existing process as possible.

Test Temperatures

The fuels will be evaluated at cool ambient temperatures. Every attempt will be made to perform testing from 30°F to 40°F; however, if weather conditions are not cooperative, it may be necessary to expand the upper end of the range. The workshop will not be as long as a test program, so there will be less flexibility in dropping days due to weather. The flexibility of the participants in which days are worked will be important.

Test Location

The test program will be conducted at the same location as the 2003 Volatility Program (Renegade Raceways) in Yakima, Washington, where the desired ambient conditions occur in late January through February and late October through November.

Timing

The workshop is planned for February 7 – 19, 2005, with set-up the week of January 31, 2005. In the first week of testing, a series of new test patterns will be evaluated. In the second week, the best test pattern or best two test patterns will be evaluated on all the vehicles to evaluate the ability to discriminate fuels and the reproducibility of the results. In addition, subjective data will be gathered to detect any faults in the process that may need correction. The last day will be used to remove test equipment and make the vehicles ready for shipping and prepare the equipment for storage.

Personnel Requirements

The program will require seven people on-site for each testing week for a total of fourteen person-weeks. Required will be two rating teams each consisting of a driver/rater and an observer/data recorder, two fueling personnel, and one program leader. It would be highly desirable to have the very best people in each job available for the entire two-week period. This will be much more challenging than a standard test program, and requires innovative people with a fundamental understanding of both the purpose and the "physics" of what is happening in every phase of the process from defueling to refueling to prep to testing to data analysis. (A test that does not account for the eventual use of the data may be sub-optimal.) Also, it would be good to have a significant number of people with hybrid experience, an understanding of the potential pitfalls in testing them, and an appreciation of how they are controlled. It is suggested that the observers all be either driveability or hybrid experts. The fuel team will be charged with devising an appropriate vehicle preparation process.

Table B-1

Test Fuel Specifications
2005 CRC Hybrid Workshop

Composition	**Test Method**	**1100 DI Fuel**	**1300 DI Fuel**
DVPE, psi	D 5191	11.8 – 12.2	11.8 – 12.2
10% Evaporated, °F	D 86	110 - 125	110 - 125
50% Evaporated, °F	D 86	185 - 200	240 - 255
90% Evaporated, °F	D 86	300 - 330	335 - 365
Driveability Index	D 4814	1050 – 1100	1300 – 1325
Aromatics, vol %	D 1319	20 - 30	20 – 45
Olefins, vol %	D 1319	0 - 10	3 – 10
Saturates, vol %	D 1319	Report	Report
Benzene, vol %	D 4815	<1.0	<1.0
MTBE, vol %	D 4815	<0.1	<0.1
Ethanol, vol %	D 4815	0	10
Lead, g/gal	D 3237	<0.05	<0.05
Washed Gum, mg/100ml	D 381	<2	<2
RON	D 2699	>90	>90
MON	D 2700	>80	>80
(R+M)/2	Calculation	>87	>87
API Gravity	D 4052	Report	Report

Both fuels are to be made using refinery gasoline blending components.
Both fuels should contain all of the appropriate carbon numbers for each hydrocarbon-type to represent commercial gasoline.

APPENDIX C

RECORDED BATTERY PACK TEMPERATURES DURING THE 2005 CRC HYBRID DRIVEABILITY WORKSHOP

RECORDED BATTERY PACK TEMPERATURES DURING THE 2005 CRC HYBRID DRIVEABILITY WORKSHOP

Date: 2/9/05 **Soak Temperature: 29°F**

Vehicle:	921	516	606	423	266	512	511	179	37
Start Time:	9:44	9:30	8:58	8:55	9:20	9:32	9:45	9:09	9:10
Start Temp, °F:	39	38	37	37	39	38	39	37	37
0.0 minutes	38.0	35.8		32.6	35.8	36.7	33.1		30.2
	36.5	36.2		31.4	37.4	35.6	34.1		31.4
	39.8	36.7		30.0	39.4	34.5	35.3		33.1
	43.7	36.7		29.3	39.1	34.4	35.5		33.5
	48.1	37.4		30.0	39.4	33.7	37.1		33.8
	52.2	38.9		31.6	40.3	34.4	38.3		43.4
30 minutes	53.6	40.3		33.3	41.9	36.0	37.6		35.3
	54.2	41.6		35.1	44.1	38.3	40.1		36.2
	53.8	42.3		36.5	46.3	40.5	41.0		37.4
	53.1	42.7			47.5	42.7	43.6		39.1
	52.0	43.0			49.5	44.5	44.8		51.3
		44.1			50.8	45.9	46.4		50.2
60 minutes		45.0			52.0	47.3	45.8		50.6
		46.1			53.3	49.3	47.7		50.6
		47.2			54.7	51.3	48.8		51.5
		47.9			56.5	52.7	49.0		54.4
		48.8			58.1	53.8	49.1		56.2
		49.3			59.4	54.4	49.0		57.1
90 minutes		49.3			59.6	54.2	49.5		59.6
		49.3			59.9	53.6	49.1		58.0
					59.6	53.5	49.1		60.5
						53.5	48.6		56.9
									56.7

Warm-up Cycle Temperatures

0.0 minutes		49.0			59.5	44.5	47.9		
5 minutes		47.9			57.4	45.4	48.6		
10 minutes		47.2			56.0	45.2	50.6		
15 minutes		46.3			51.1	43.7	52.7		
20 minutes		43.7			39.6	42.5	52.7		
25 minutes		41.9			38.0				

RECORDED BATTERY PACK TEMPERATURES DURING THE 2005 CRC HYBRID DRIVEABILITY WORKSHOP – *(Continued)*

Date: 2/10/05 **Soak Temperature: 23°F**

Vehicle:	**921**	**516**	**606**	**423**	**266**	**512**	**511**	**179**	**37**
Start Time:	9:44	9:30	8:58	8:55	9:20	9:32	9:45	9:09	9:10
Start Temp, °F:	39	38	37	37	39	38	39	37	37
0.0 minutes	33.8	20.3		26.1	23.1		22.2	56.0	19.4
	31.8	21.9		27.6	27.5		23.3	53.1	22.1
	32.0	23.0		28.7	30.5		24.8	53.1	25.1
	36.9	23.7		28.5	31.1		25.8	55.6	25.8
	42.3	24.6		29.3	32.2		26.9	56.9	27.1
	47.2	25.7		30.9	33.7		28.2	58.0	28.4
30 minutes	52.4	27.1		32.8	35.3		30.0	59.0	29.8
	55.3	29.1		34.7	37.8		32.2	60.5	32.8
	55.3	31.2		36.9	40.1		33.8	61.6	35.6
	48.1			39.1				63.0	
	41.6			41.4	45.3				
60 minutes									

Warm-up Cycle Temperatures

0.0 minutes	40.5	37.6	46.6	53.6	50.8	47.0	46.6	89.5	54.4
5 minutes	38.0	38.3	47.3	53.6	50.9	44.1	45.7	80.6	57.2
10 minutes		39.1	47.7	54.9	49.7	41.4	46.1	70.6	
15 minutes		38.9	48.8	53.8	46.4	38.5	45.2	68.2	

Vehicle 179 recorded 87°F at end of warm-up using the generic scan tool. The OEM scan tool for that vehicle showed 98°F at end of warm-up.

RECORDED BATTERY PACK TEMPERATURES DURING THE 2005 CRC HYBRID DRIVEABILITY WORKSHOP – *(Continued)*

Date: 2/11/05 **Soak Temperature: 29°F**

Vehicle:	**921**	**516**	**606**	**423**	**266**	**512**	**511**	**179**	**37**
Start Time:	8:39	8:45	9:00	9:45	9:02	9:47	9:15	9:30	9:30
Start Temp, °F:	36	36	36	41	38	41	40	40	40
0.0 minutes	34.9		23.4	30.9	24.0	30.2	30.2	49.3	30.9
	34.2		28.1	31.4	27.5	32.0	30.3	52.9	33.1
	31.4		28.9	33.5	29.4	32.1	31.1	52.2	37.1
	36.5		30.0	35.5	30.3	32.2	32.2	52.6	39.4
	43.0		31.8	36.9	30.9	32.3	33.5	52.2	39.6
	49.0		33.1	37.6	32.0	34.1	34.7	51.7	40.0
30 minutes	50.2		34.4	38.2	33.8	36.5	35.0	52.0	41.0
	51.5		35.3	38.5	36.2	39.1	35.9	52.4	42.5
	53.3		36.2	39.1	38.3	41.6	37.8	53.6	44.1
	56.6		37.3	39.4	40.7	44.3	38.5	54.7	45.5
			38.0	39.8	42.8	46.4	39.2	56.0	47.2
			38.7	40.1	44.8	48.2	39.8	56.7	48.8
60 minutes			39.2	40.5	47.0	48.6	40.1	58.0	50.4
			40.0	40.7	49.1	48.8	40.1	58.5	52.0
			40.3	41.0	51.3	49.5	41.4	59.2	63.2
			40.5	41.4	53.3	50.4	41.9	59.9	83.5
			40.7	41.6	55.1	50.8	42.3	61.4	75.6
			41.0	41.8	57.1	51.3	42.8	62.1	72.5
90 minutes			41.6	42.1	58.7	51.3	43.6	62.6	73.3
			42.3	42.3	60.7	51.7	44.1	63.2	71.6
			42.5	42.5	60.8	51.7	44.5	63.7	70.6
			43.7	42.7	57.6		44.6	63.5	69.5
			43.6	42.8	54.4		44.8	63.7	67.7
			43.2	43.0	54.0		45.4	62.8	66.6
120 minutes			43.2	43.4	52.9		44.8		
				43.6			45.2		
				44.1			45.4		
				44.1					
				44.3					

Warm-up Cycle Temperatures

0.0 minutes	53.3	47.3	43.4	44.5	52.7	51.5	45.2	63.7	65.9
5 minutes	48.2	50.0	42.7	46.4	57.2	51.5	45.9	60.7	63.5
10 minutes		52.0	42.8	49.1	58.3	50.8	47.2	59.0	60.5
15 minutes		52.6	44.6		55.6		49.1	57.6	56.5
20 minutes		52.6							

Vehicle 179 recorded 35°F at start of test and 50°F at end of test using the OEM scan tool.

RECORDED BATTERY PACK TEMPERATURES DURING THE 2005 CRC HYBRID DRIVEABILITY WORKSHOP – *(Continued)*

Date: 2/12/05 **Soak Temperature: 27°F**

Vehicle:	**921**	**516**	**606**	**423**	**266**	**512**	**511**	**179**	**37**
Start Time:	8:55	9:53	9:45	9:14	9:15	10:15	9:33	9:30	8:55
Start Temp, °F:	36	38	39	37	37	42	38	38	36
0.0 minutes	32.2	34.0	30.7	30.0	30.9		30.9	42.1	23.5
	29.4	35.5	30.9	30.7	32.9		31.2	44.3	25.1
	23.9	36.5	31.2	32.8	35.1		32.2	45.4	27.5
	26.6	36.7	32.8	35.5	35.1		33.5	46.4	28.9
	30.9	36.7	34.4	37.3	34.2		34.9	47.5	29.8
	34.2	36.9	35.8	38.2	34.0		36.2	49.1	29.8
30 minutes	36.5	37.4	36.9	38.7	34.4		37.1	50.8	30.0
	39.1	37.8	37.6	39.2	34.7		38.0	51.8	30.3
	41.9	38.2	38.3	39.6	35.8		38.7	53.1	30.9
	44.5	38.7	39.1	39.8	37.4		39.2	54.4	31.4
	45.9		39.6	40.1	39.4			54.0	32.0
			40.0	40.5	41.4				32.4
60 minutes			40.3	40.7	47.5				33.1
				41.0					34.2
				41.4					35.5
				41.6					36.5
				41.6					37.6
				41.8					38.7
90 minutes									39.6
									40.3
									40.7
									41.6

Warm-up Cycle Temperatures

0.0 minutes	44.1		42.8	42.8	48.1			58.5	42.1
5 minutes			43.0	44.5	47.7			55.4	41.8
10 minutes			43.7	47.9	44.6			54.9	40.5
15 minutes			45.4					54.7	38.5
20 minutes								55.1	

Vehicle 179 recorded 35°F at start of test, 41°F at 0.5 idle, 48°F at 0.7 idle, 55°F at 1.2 idle, 60°F at 1.7 idle using the OEM scan tool.

RECORDED BATTERY PACK TEMPERATURES DURING THE 2005 CRC HYBRID DRIVEABILITY WORKSHOP – *(Continued)*

Date: 2/13/05 **Soak Temperature: 26°F**

Vehicle:	**921**	**516**	**606**	**423**	**266**	**512**	**511**	**179**	**37**
Start Time:	8:35	9:19	8:45	8:15	8:49	9:20	8:18	8:35	9:05
Start Temp, °F:	39	45	42	36	42	45	36	39	41
0.0 minutes	22.4	27.5	28.5	30.2	21.9	32.9	29.8	40.1	28.9
	22.8	29.3	28.7	31.1	25.5	34.6	30.2	43.0	32.8
	20.6	30.9	29.4	32.2	25.7	35.5	31.2	47.5	35.5
	27.8	31.4	30.9	34.6	25.3	35.3	32.6	49.3	36.0
	36.2	32.4	32.4	36.2	25.8	36.2	34.0	50.2	36.7
	44.1	33.7	32.9	37.1	25.9	38.3	35.3	51.3	37.6
30 minutes	50.6	35.3	33.8	37.6	28.2	41.4	35.7	52.6	38.5
	55.6	37.1	34.4	38.3	29.6	44.3	37.6	53.8	40.0
		38.7	35.1	38.9	31.4	45.8	38.7	54.9	41.6
		40.3	36.0	39.4	33.5	49.5	39.6	55.6	43.0
		42.1	36.5	40.0	35.3	52.2	40.3	56.5	44.6
		43.7	37.4	40.3	37.3	54.0	41.2	57.2	46.3
60 minutes		45.7		40.5	39.4	54.2	41.8	58.3	47.5
		47.0		41.0	41.9	52.7	42.5	58.9	49.0
		47.7		41.2	44.1	50.2	43.0	59.8	50.4
				41.6	46.1		43.6	60.5	50.0
				41.8	47.9		44.1	60.8	45.5
				42.1	48.6		44.6	61.9	40.3
90 minutes					48.8			61.7	
								62.6	
								59.2	
								53.6	
								51.1	

Warm-up Cycle Temperatures

0.0 minutes	55.6		38.3	42.5			45.0		
5 minutes			39.4	43.7			46.3		
10 minutes			41.4	46.3			47.5		
15 minutes			43.2	49.3			49.5		

RECORDED BATTERY PACK TEMPERATURES DURING THE 2005 CRC HYBRID DRIVEABILITY WORKSHOP – *(Continued)*

Date: 2/14/05 **Soak Temperature: 23°F**

Vehicle:	**921**	**516**	**516***	**606**	**423**	**266**	**512**	**511**	**179**	**37**
Start Time:	9:20	8:45		8:10	8:15	9:20	9:00	8:50	8:30	9:05
Start Temp, °F:	40	36		34	34	40	39	36	34	39
0.0 minutes	37.4	23.0		20.3	23.7	29.3	30.2	21.5		
	34.0	23.7		20.1	24.0	31.6	29.4	23.1		
	30.3	24.6		21.9	25.7	32.4	30.7	25.0		
	34.9	25.0		22.3	28.2	34.2	29.3	27.3		
	41.4	25.8		24.0	31.4	34.2	29.3	29.1		
	46.4	26.9		25.1	33.5	34.3	30.9	30.9		
30 minutes	50.8	28.4		26.2	34.9	38.3	32.8	32.4		
	53.6	30.2		26.9	35.6	41.0	35.1	33.7		
	56.3	32.2		27.3	36.4	44.1	37.3	34.7		
	58.5	33.8		23.4	36.7	46.4	39.6	35.6		
	58.7	35.5		29.1	37.3	49.5	42.3	36.4		
	51.3	37.1		29.8	37.4	52.6	44.8	37.3		
60 minutes		38.5		30.7	37.8	56.0		37.8	34.9	
		40.0		31.4	38.2	58.0		38.5	35.3	
		41.6		32.2	38.3			39.1	33.3	
		42.8		32.9	38.5	61.0			32.6	
		44.5		33.7	38.9	63.4			32.4	
		45.4		34.4	39.1	65.7			32.8	
90 minutes		46.4		35.1	39.2	67.9			34.4	
		47.2		35.6	39.2	69.8			38.7	
		48.1		35.4	39.8				38.9	
		45.4		37.4	40.0				38.9	
		45.7							38.9	
120 minutes									39.6	

Warm-up Cycle Temperatures

0.0 minutes	0.0	46.6	43.4	38.2	40.5	72.0	47.2	40.0	40.1	41.9
5 minutes		48.1	44.3	39.2	43.2	42.5	49.7	41.4	40.7	44.3
10 minutes		48.8	46.8	40.7	46.1	69.1	50.0	42.8	41.2	45.2
15 minutes		48.8	51.1	42.1	49.5	62.5	47.9	44.6	47.5	42.7
20 minutes									50.4	37.8

**Vehicle 516 had a second thermocouple installed in the intake air of the battery pack after testing on 2/14/05. The column without the asterisk gives the temperature as taken on the battery skin; the column with the asterisk shows the temperature as taken with the new thermocouple.*

RECORDED BATTERY PACK TEMPERATURES DURING THE 2005 CRC HYBRID DRIVEABILITY WORKSHOP – *(Continued)*

Date: 2/15/05 **Soak Temperature: 27°F**

Vehicle:	**921**	**516**	**516***	**606**	**423**	**266**	**512**	**511**	**179**	**37**
Start Time:	8:45	9:40		9:20	9:05	8:30	8:30	9:20	8:45	9:40
Start Temp, °F:	34	38		36	35	34	34	36	34	38
0.0 minutes	31.2	29.6	37.4	28.0	29.6	20.5	17.7	29.6	30.9	32.8
	28.4	30.7	37.4	28.0	30.3	22.3	13.5	29.8	32.6	33.1
	23.1	30.9	38.7	28.7	32.2	23.0	13.5	31.1	34.0	34.2
	27.1	31.1	41.0	30.0	34.9	23.3	18.1	32.6	34.4	35.3
	32.8	30.9	42.7	31.6	37.1	23.5	17.9	34.0	34.6	36.4
	37.4	31.1	43.4	32.9	38.2	24.2	19.2	35.5	34.7	37.6
30 minutes	41.4	31.8	43.7	34.0	38.7	25.1	21.0	36.5	34.9	38.5
	44.8	32.8	44.3	34.9	39.2	27.6	23.1	37.4	35.1	39.4
	47.5	33.8	44.3	35.8	39.8	29.6	23.3	38.3	35.1	40.5
		34.7	44.6	36.5	40.1	31.8	27.8	39.1	35.3	41.9
				37.3	40.5	34.0	30.0	39.8	35.5	
				38.0	40.7	36.0	32.2	40.3	35.5	
60 minutes				38.6	41.2	38.2	34.2	41.0	35.6	
					41.8	40.1	36.0	41.6	35.8	
					41.9	42.5	37.8	42.1	36.7	
					42.1	44.6	39.4	42.5	38.3	
					42.5	46.4	41.3	42.8	38.3	
					42.7	48.2	42.5		38.3	
90 minutes					43.0	50.0	43.7		38.5	
						51.8	45.0		38.7	
						53.5	46.4		38.9	
						55.1	47.9		39.1	
						57.1	49.3		39.2	
									39.4	

Warm-up Cycle Temperatures

0.0 minutes	50.4	35.8	45.5	40.7	43.2	58.5	51.5	44.5	39.6	42.8
5 minutes	47.3	36.5	48.8	42.5	45.0	57.2	51.7	45.4	48.6	42.7
10 minutes				44.3	47.5	53.1	49.7	47.0	49.1	39.2
15 minutes					51.5	47.7	45.4		50.4	

**Vehicle 516 had a second thermocouple installed in the intake air of the battery pack after testing on 2/14/05. The column without the asterisk gives the temperature as taken on the battery skin; the column with the asterisk shows the temperature as taken with the new thermocouple.*

RECORDED BATTERY PACK TEMPERATURES DURING THE 2005 CRC HYBRID DRIVEABILITY WORKSHOP – *(Continued)*

Date: 2/16/05 **Soak Temperature: 27°F**

Vehicle:	**921**	**516**	**516***	**606**	**423**	**266**	**512**	**511**	**179**	**37**
Start Time:	8:30	8:10		9:10	8:50	8:35	9:25	9:10	9:30	8:25
Start Temp, °F:	34	34		37	35	34	37	37	37	35
0.0 minutes	25.8	22.2	35.5	25.5	27.3	21.5	29.3	28.2	31.2	19.0
	23.7	23.5	35.6	25.7	28.4	25.2	30.2	28.5	32.9	20.3
	19.2	23.7	36.1	27.3	29.6	27.3	30.7	29.1	35.3	21.7
	18.8	23.7	37.6	23.4	32.6	27.3	29.6	32.2	36.9	23.5
	14.5	23.5	40.5	31.4	36.5	27.3	31.2	33.7	36.5	24.2
30 minutes	12.7	23.9	41.1	32.5	37.3	27.3	33.1	35.1	36.7	25.5
	11.8	24.8	41.2	33.3	37.6	27.3	35.3	36.2	36.9	26.9
	9.6	25.8	41.4	34.2	38.2	25.7	37.5	36.9	37.3	28.4
	15.4	27.3	41.6	34.9	38.5	25.2	40.0	37.8	37.3	29.8
		28.5	41.8	35.6	38.7	25.1	42.5	38.3	37.6	31.6
				35.2	39.1	24.8		39.1	37.8	33.1
60 minutes					39.4	25.1		40.0	37.8	34.6
					39.6	25.5		41.2	38.7	36.0
					39.8	25.8		42.7	40.5	37.3
					40.0	25.8		44.3	40.1	38.5
					40.1	27.1		45.9	40.5	40.5
					40.3	27.6		47.5	40.7	41.8
90 minutes					40.5	28.0		49.1	41.0	42.8
						28.2		51.1	41.2	43.7
						28.4		52.6	41.4	45.0
						29.4		54.2	41.6	45.9
						30.3		55.6	41.8	
						32.8		58.3	42.1	
120 minutes						34.9			42.5	
						35.4			42.8	

Warm-up Cycle Temperatures

Vehicle:	**921**	**516**	**516***	**606**	**423**	**266**	**512**	**511**	**179**	**37**
0.0 minutes						34.7				46.8
5 minutes						35.1				46.6
10 minutes						35.6				45.7
15 minutes						37.1				
20 minutes						38.2				

**Vehicle 516 had a second thermocouple installed in the intake air of the battery pack after testing on 2/14/05. The column without the asterisk gives the temperature as taken on the battery skin; the column with the asterisk shows the temperature as taken with the new thermocouple.*

RECORDED BATTERY PACK TEMPERATURES DURING THE 2005 CRC HYBRID DRIVEABILITY WORKSHOP – *(Continued)*

Date: 2/17/05 **Soak Temperature: 25°F**

Vehicle:	921	516	516*	606	423	266	512	511	179	37
Start Time:	8:25	8:10		8:40	9:00	8:45	9:10	8:10	9:15	8:15
Start Temp, °F:	35	34		35	36	35	37	34	38	34
0.0 minutes	22.1	18.8	24.9	24.9	27.3	25.7	25.3	25.3	29.8	18.3
	21.2	19.5	34.9	25.3	28.4	26.5	26.9	25.4	30.3	19.7
	18.1	20.1	35.8	25.2	30.2	28.2	27.3	25.7	32.6	20.8
	22.6	20.4	37.1	27.1	33.5	28.1	27.3	28.0	35.8	21.7
	29.3	20.5	39.2	28.9	35.5	28.2	27.3	29.3	35.5	22.4
	34.9	21.0	40.0	30.2	36.4	28.5	28.5	30.9	35.6	23.1
30 minutes	39.6	21.9	40.3	31.2	37.1	29.3	30.2	32.4	35.6	23.9
	43.7	22.6	40.5	32.0	37.6	31.1	32.2	33.5	35.8	25.1
	47.2	23.7	41.0	32.8	38.2	33.7	34.2	34.2	36.0	26.6
	49.1	25.1	41.0	33.5	38.5	35.6	35.8	35.1	36.4	27.6
	49.0	26.7	41.2	34.2	38.9	38.0	37.6	35.8	36.5	29.1
	50.4	28.2	41.2	34.9	39.1	40.3	39.1	36.4	36.5	30.3
60 minutes	52.6	29.6	41.4	35.6	39.4	42.7	40.7	36.9	36.7	31.8
		31.2	41.4	36.2	39.6	44.8	42.3	37.4	36.9	32.9
		32.8	41.6	36.9	40.0	46.8	43.6	38.0	37.3	43.0
		34.2	41.6	37.4	40.1	49.0		38.3	37.4	35.1
		35.5	41.6	38.2	40.3	50.9			37.6	35.8
				38.7	41.0	59.9			38.0	37.1
90 minutes					41.9	54.7			38.0	38.5
					42.5	56.7			38.2	39.8
						58.3			41.0	41.2
						60.5				42.7
						62.1				44.2
						63.5				42.7
120 minutes						64.4				44.1
						65.9				

Warm-up Cycle Temperatures

0.0 minutes	55.1	36.7	41.6		44.6	67.1			49.0	45.4
5 minutes	57.4	37.8	41.6		47.2	66.8			49.7	46.4
10 minutes	56.7	38.7	41.8		49.0	63.2			49.5	47.7
15 minutes						58.7				49.0
20 minutes										50.4

**Vehicle 516 had a second thermocouple installed in the intake air of the battery pack after testing on 2/14/05. The column without the asterisk gives the temperature as taken on the battery skin; the column with the asterisk shows the temperature as taken with the new thermocouple.*

RECORDED BATTERY PACK TEMPERATURES DURING THE 2005 CRC HYBRID DRIVEABILITY WORKSHOP – *(Continued)*

Date: 2/18/05 **Soak Temperature: 30°F**

Vehicle:	**921**	**516**	**516***	**606**	**423**	**266**	**512**	**511**	**179**	**37**
Start Time:	8:30	7:55		8:15	8:30	9:02	8:45	8:45	7:55	8:15
Start Temp, °F:	36	34		35	35	37	37	37	34	35
0.0 minutes	30.3	23.1	39.6	28.0	30.9	33.1	27.1	30.7	31.1	22.6
	37.5	23.7	39.5	27.8	31.4	35.3	27.8	31.1	32.2	23.7
	23.1	23.7	39.2	28.4	32.6	35.6	27.6	31.8	32.9	24.0
	27.3	23.5	41.9	29.6	35.1	35.1	26.6	33.1	33.3	
	32.2	23.1	43.9	31.1	37.4	34.9	26.4	34.6	33.8	25.8
	36.5	23.1	44.3	32.2	38.5	35.8	27.3	36.0	24.2	26.7
30 minutes	37.6	23.7	44.6	32.9	39.1	36.7	28.9	37.1	34.4	27.5
	39.4	24.6	45.0	33.7	39.0	38.0	31.1	38.2	34.4	28.5
	41.4	25.7	45.2	34.4	39.8	39.8	33.1	39.1	34.7	29.4
		25.3	45.4	34.9	40.1	41.2	35.3	39.6	34.7	30.9
		28.7	45.5	35.6	40.1	41.2	37.3	40.3	34.9	31.8
		30.2	45.5	36.2	40.0	40.5	39.2		34.9	32.9
60 minutes		31.6	45.5	35.6	40.3	40.1	41.2		35.1	34.2
		32.9	45.5		40.7	41.2				35.5
		34.0	45.5		41.2	41.6				
		35.3	45.7		41.4					
		36.4	45.7		41.8					
		37.4	45.7		41.9					
90 minutes					42.1					

Warm-up Cycle Temperatures

0.0 minutes	*Last day of testing; therefore, no warm-up cycle was driven.*
5 minutes	
10 minutes	
15 minutes	
20 minutes	

**Vehicle 516 had a second thermocouple installed in the intake air of the battery pack after testing on 2/14/05. The column without the asterisk gives the temperature as taken on the battery skin; the column with the asterisk shows the temperature as taken with the new thermocouple.*

APPENDIX D

RAW DATA SUMMARY OF THE

2005 CRC HYBRID DRIVEABILITY WORKSHOP

RAW DATA SUMMARY FOR THE
2005 CRC HYBRID DRIVEABILITY WORKSHOP

(Practice Day – This day's results are included for information only and should not be used)

Date	Vehicle	Fuel	Rater	Soak Temp,°F	Run Temp,°F	TWD
2/3	921	pump	ARC	30	32	11
2/3	345	pump	ARC	30	32	46.5
2/3	516	pump	ARC	30	31	29
2/3	606	pump	ARC	30	32	22
2/3	423	pump	PVA	30	32	15
2/3	266	pump	PVA	30	32	8
2/3	512	pump	PVA	30	32	22
2/3	511	pump	PVA	30	32	45
2/3	179	*(Vehicle had not yet arrived at the test site)*				
2/3	37	*(Vehicle had not yet arrived at the test site)*				

(Practice Day – This day's results are included for information only and should not be used)

2/4	921	1300	PVA	32	38	32
2/4	345	1300	PVA	32	36	78.3
2/4	516	1300	PVA	32	37	47
2/4	606	1300	ARC	32	36	36
2/4	423	1300	ARC	32	35	29
2/4	266	1300	ARC	32	37	18
2/4	512	1300	ARC	32	38	36
2/4	511	1300	PVA	32	35	23
2/4	179	*(Vehicle had not yet arrived at the test site)*				
2/4	37	*(Vehicle had not yet arrived at the test site)*				

RAW DATA SUMMARY FOR THE
2005 CRC HYBRID DRIVEABILITY WORKSHOP - *(Continued)*

Date	Vehicle	Fuel	Rater	Soak Temp,°F	Run Temp,°F	TWD
2/7	921	1300	PVA	32	39	36
2/7	345	1300	PVA	32	38	102.5
2/7	516	1300	ARC	32	39	29
2/7	606	1300	ARC	32	40	25
2/7	423	1300	ARC	32	38	18
2/7	266	1300	PVA	32	41	43
2/7	512	1300	ARC	32	38	20
2/7	511	1300	PVA	32	38	30
2/7	179	1300	ARC	32	40	4
2/7	37	*(Vehicle had not yet arrived at the test site)*				
2/8	921	1300	PVA	32	39	47
2/8	345	1300	ARC	32	37	83
2/8	516	1300	ARC	32	37	29
2/8	606	1300	PVA	32	37	54
2/8	423	1300	PVA	32	41	52
2/8	266	1300	ARC	32	39	28
2/8	512	1300	PVA	32	39	28
2/8	511	1300	ARC	32	39	23
2/8	179	1300	PVA	32	37	48
2/8	37	*(Vehicle had not yet arrived at the test site)*				
2/9	921	1100	PVA	29	39	30
2/9	345	1100	PVA	29	39	63.5
2/9	516	1100	ARC	29	38	30
2/9	606	1100	PVA	29	37	55
2/9	423	1100	ARC	29	37	22
2/9	266	1100	ARC	29	39	1
2/9	512	1100	PVA	29	38	38
2/9	511	1100	ARC	29	39	16
2/9	179	1100	PVA	29	37	13
2/9	37	1100	ARC	29	37	25

Preconditioning for testing done on the 7th used "bunny hops" and 1300 DI fuel as discussed in Section VI, Test Program. Testing on the 8th did not use "bunny hops" during the preconditioning cycle, but did use 1300 DI fuel. Testing on the 9th used "bunny hops" for preconditioning and 1100 DI fuel, and testing on the 10th did not use "bunny hops," but did use 1100 DI fuel.

RAW DATA SUMMARY FOR THE
2005 CRC HYBRID DRIVEABILITY WORKSHOP - *(Continued)*

Date	Vehicle	Fuel	Rater	Soak Temp,°F	Run Temp,°F	TWD
2/10	921	1100	PVA	23	39	27
2/10	345	1100	ARC	23	36	35
2/10	516	1100	PVA	23	37	63
2/10	606	1100	PVA	23	37	30
2/10	423	1100	ARC	23	39	48
2/10	266	1100	ARC	23	37	1
2/10	512	1100	PVA	23	40	51
2/10	511	1100	ARC	23	37	18
2/10	179	1100	ARC	23	40	3
2/10	37	1100	PVA	23	36	14
2/11	921	1300	ARC	29	41	52
2/11	345	1300	PVA	29	40	86.5
2/11	516	1300	ARC	29	36	53
2/11	606	1300	ARC	29	36	39
2/11	423	1300	PVA	29	36	63
2/11	266	1300	PVA	29	38	83
2/11	512	1300	PVA	29	41	52
2/11	511	1300	ARC	29	40	47
2/11	179	1300	PVA	29	40	49
2/11	37	1300	ARC	29	40	100
2/12	921	1300	PVA	27	36	78
2/12	345	1300	PVA	27	40	197.5
2/12	516	1300	PVA	27	38	141
2/12	606	1300	ARC	27	39	76
2/12	423	1300	PVA	27	37	146
2/12	266	1300	ARC	27	37	57
2/12	512	1300	ARC	27	42	52
2/12	511	1300	PVA	27	38	87
2/12	179	1300	ARC	27	38	86
2/12	37	1300	ARC	27	36	74

RAW DATA SUMMARY FOR THE
2005 CRC HYBRID DRIVEABILITY WORKSHOP - *(Continued)*

Date	Vehicle	Fuel	Rater	Soak Temp,°F	Run Temp,°F	TWD
2/13	921	1300	ARC	26	39	56
2/13	345	1300	ARC	26	41	90.5
2/13	516	1300	PVA	26	45	114
2/13	606	1300	ARC	26	42	71
2/13	423	1300	ARC	26	36	72
2/13	266	1300	PVA	26	42	98
2/13	512	1300	ARC	26	45	61
2/13	511	1300	PVA	26	36	58
2/13	179	1300	PVA	26	39	50
2/13	37	1300	PVA	26	41	209
2/14	921	1300	PVA	23	40	107
2/14	345	1300	PVA	23	34	225.5
2/14	516	1300	PVA	23	36	173
2/14	606	1300	PVA	23	34	124
2/14	423	1300	ARC	23	34	109
2/14	266	1300	ARC	23	40	142
2/14	512	1300	PVA	23	39	128
2/14	511	1300	ARC	23	36	65
2/14	179	1300	ARC	23	34	83
2/14	37	1300	ARC	23	39	169
2/15	921	1300	PVA	27	34	97
2/15	345	1300	PVA	27	35	229
2/15	516	1300	PVA	27	38	161
2/15	606	1300	PVA	27	36	126
2/15	423	1300	ARC	27	35	132
2/15	266	1300	ARC	27	34	69
2/15	512	1300	PVA	27	34	82
2/15	511	1300	ARC	27	36	69
2/15	179	1300	ARC	27	34	83
2/15	37	1300	ARC	27	38	201

RAW DATA SUMMARY FOR THE
2005 CRC HYBRID DRIVEABILITY WORKSHOP - *(Continued)*

Date	Vehicle	Fuel	Rater	Soak Temp,°F	Run Temp,°F	TWD
2/16	921	1300	PVA	32	34	89
2/16	345	1300	PVA	32	35	243
2/16	516	1300	PVA	32	34	108
2/16	606	1300	PVA	32	37	178
2/16	423	1300	ARC	32	35	139
2/16	266	1300	ARC	32	34	114
2/16	512	1300	PVA	32	37	98
2/16	511	1300	ARC	32	37	59
2/16	179	1300	ARC	32	37	88
2/16	37	1300	ARC	32	34	185
2/17	921	1100	PVA	25	35	94
2/17	345	1100	PVA	25	37	163
2/17	516	1100	PVA	25	34	127
2/17	606	1100	PVA	25	35	143
2/17	423	1100	ARC	25	36	74
2/17	266	1100	ARC	25	35	15
2/17	512	1100	PVA	25	37	114
2/17	511	1100	ARC	25	34	72
2/17	179	1100	ARC	25	38	16
2/17	37	1100	ARC	25	35	38
2/18	921	1100	PVA	30	36	92
2/18	345	1100	PVA	30	38	236
2/18	516	1100	PVA	30	34	163
2/18	606	1100	PVA	30	35	152
2/18	423	1100	ARC	30	35	131
2/18	266	1100	ARC	30	37	19
2/18	512	1100	PVA	30	37	137
2/18	511	1100	ARC	30	37	50
2/18	179	1100	ARC	30	34	48
2/18	37	1100	ARC	30	35	41

APPENDIX E

CRC COLD-START AND WARM-UP
DRIVEABILITY PROCEDURE
(E-28-94)

REVISED CRC COLD-START AND WARM-UP 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 Owner's Manual procedure. If the engine fails to start after 5 seconds during the third attempt, record an "NS" in the Restart 2 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 may be recorded; however, only one stall 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 warm-up before the driving maneuvers and to maintain vehicle spacing on the test track.

E. After idling 5 seconds (Step D), make a brief 0-15 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 0-15 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 driveability 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 5. 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 7, 28, 50, and 100 for idle and maneuvering stalls 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.

Other malfunctions, such as hesitation, stumble, surge, idle roughness, and backfire, are rated subjectively by the driver on a scale of trace, moderate, heavy, or extreme. For these malfunctions, a certain number of demerits is assigned to each of the subjective ratings. Since all malfunctions are not of equal importance, however, 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.

When all the factors are multiplied together the following chart of demerit levels is generated.

Demerit levels for: Hesitation/Stumble/Surge/Backfire/Stall

Maneuver	Stall	Extreme	Heavy	Medium	Trace	Clear
Light Throttle	50	16	8	4	2	0
Medium Throttle	100	32	16	8	4	0
WOT	100	32	16	8	4	0
Detent	50	16	8	4	2	0
Crowd	50	16	8	4	2	0

For Idle Roughness

Extreme	Heavy	Medium	Trace	Clear
8	4	2	1	0

For Idle Stalls

Idle-in- Park	Starting-in-Drive	Other Idle (after moderate throttle or at end of test)
7 each	28	7

For Starting

No Start	**Slow Start**
25 each	t-1*5

The Start time, t, is in seconds.

Only the results (start, start + stall, no-start) of the first three starting attempts in park count toward demerits.

Only the first stall in drive prior to maneuvering counts toward demerits

Only the first stall in each maneuver, or in each idle subsequent to the start of the maneuver is counted toward demerits.

Only the highest weighted demerit score from each maneuver is counted.

APPENDIX F

DATA SHEETS USED DURING THE 2005 CRC HYBRID DRIVEABILITY WORKSHOP

CRC Driveability Data Sheet

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

Starting time, Sec.: Initial | Restart 1 | Restart 2

Idle Park: Ruf Stls

Idle Drive: Ruf Stls

0.0 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

0.1 0-20 WOT
H S B
E T S K A D
S M G F C C

0.2 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

0.3 10-20 LT TH
H S B
E T S K A D
S M G F C C

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 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

0.6 0-20 WOT
H S B
E T S K A D
S M G F C C

0.7 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

0.8 10-20 LT TH
H S B
E T S K A D
S M G F C C

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

CRC Driveability Hybrid Data Sheet

Run No. Car Fuel Rater Date Time

Temperatures Soak Run

Odometer

Starting time, Sec.

Initial Restart 1 Restart 2

Idle Park

Ruf Stls

Idle Drive

Ruf Stls

0.0 0-15 LT TH

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

0-15 LT TH

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

0.1 0-20 WOT

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

0.2 0-15 LT TH

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

0-15 LT TH

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

0.3 10-20 LT TH

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

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.
5 sec.

Ruf Stls

Idle Dr.
30 sec.

Ruf Stls

0.5 0-15 LT TH

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

0-15 LT TH

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

0.6 0-20 WOT

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

0.7 0-15 LT TH

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

0-15 LT TH

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

0.8 10-20 LT TH

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

0.9 0-20 MD TH

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

1.0 Idle Dr.
5 sec.

Ruf Stls

Idle Dr.
30 sec.

Ruf Stls

CRC Driveability Hybrid Data Sheet (Page 2)

Run
No. Car Rater Date

1.0 0-15 LT TH

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

0-15 LT TH

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

1.1 0-20 WOT

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

1.2 0-15 LT TH

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

0-15 LT TH

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

1.3 10-20 LT TH

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

1.4 Idle Dr.
5 sec.

Ruf Stls

Idle Dr.
30 sec.

Ruf Stls

1.4 0-20 MD TH

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

1.5 Idle Dr.
5 sec.

Ruf Stls

Idle Dr.
30 sec.

Ruf Stls

CRC Driveability Hybrid Data Sheet

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

Starting time, Sec.			Idle Park	Idle Drive
Initial	Restart 1	Restart 2	Ruf Stls	Ruf Stls

0.0 0-20 MD TH	0-15 LT TH	0.1 0-20 MD	0-15 LT TH	0.2 0-20 MD TH	0-15 LT TH
H S B	H S B	H S B	H S B	H S B	H S B
E T S K A D	E T S K A D	E T S K A D	E T S K A D	E T S K A D	E T S K A D
S M G F C C	S M G F C C	S M G F C C	S M G F C C	S M G F C C	S M G F C C

0.3 0-20 MD TH	0-15 LT TH	0.4 0-20 WOT	0.5 Idle Dr. 5 sec.	Idle Dr. 30 sec.
H S B	H S B	H S B	Ruf Stls	Ruf Stls
E T S K A D	E T S K A D	E T S K A D		
S M G F C C	S M G F C C	S M G F C C		

0.5 0-20 MD TH	0-15 LT TH	0.6 0-20 MD	0-15 LT TH	0.7 0-20 MD TH	0-15 LT TH
H S B	H S B	H S B	H S B	H S B	H S B
E T S K A D	E T S K A D	E T S K A D	E T S K A D	E T S K A D	E T S K A D
S M G F C C	S M G F C C	S M G F C C	S M G F C C	S M G F C C	S M G F C C

0.8 0-20 MD TH	0-15 LT TH	0.9 0-20 WOT	1.0 Idle Dr. 5 sec.	Idle Dr. 30 sec.
H S B	H S B	H S B	Ruf Stls	Ruf Stls
E T S K A D	E T S K A D	E T S K A D		
S M G F C C	S M G F C C	S M G F C C		

CRC Driveability Hybrid Data Sheet (Page 2)

Run No. | Car | Rater | Date

1.0 0-20 MD TH
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

1.1 0-20 MD
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

1.2 0-20 MD TH
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

1.3 0-20 MD TH
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

1.4 0-20 WOT
H S B
E T S K A D
S M G F C C

1.5 Idle Dr.
5 sec.
Ruf Stls

Idle Dr.
30 sec.
Ruf Stls

Turn HVAC Off
At this Point
Everything off

HVAC Off

1.5 0-20 MD TH
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

1.6 0-20 MD
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

1.7 0-20 MD TH
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

1.8 0-20 MD TH
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

1.9 0-20 WOT
H S B
E T S K A D
S M G F C C

2.0 Idle Dr.
5 sec.
Ruf Stls

Idle Dr.
30 sec.
Ruf Stls

CRC Driveability Hybrid Data Sheet

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

Starting time, Sec.			Idle Park	Idle Drive
Initial	Restart 1	Restart 2	Ruf Stls	Ruf Stls

0.0 0-20 50% TH	0-15 LT TH	0.1 0-15 LT TH	0-20 MD TH	0.2 0-15 LT TH	0-20 MD TH
H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C

0.3 0-15 LT TH	0-20 MD TH	0.4 70% TH	0.5 Idle Dr. 5 sec.	Idle Dr. 30 sec.	**Turn HVAC Off** **At this Point** Everything off	Idle Dr 15 sec.
H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	Ruf Stls	Ruf Stls	**HVAC Off**	**NO RATING**

0.5 0-20 50% TH	0-15 LT TH	0.6 0-15 LT TH	0-20 MD TH	0.7 0-15 LT TH	0-20 MD TH
H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C

0.8 0-15 LT TH	0-20 MD TH	0.9 70% TH	1.0 Idle Dr. 5 sec.	Idle Dr. 30 sec.	**Turn HVAC ON** **At this Point**	Idle Dr. 15 sec.
H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	Ruf Stls	Ruf Stls	**HVAC ON**	**NO RATING**

CRC Driveability Hybrid Data Sheet (Page 2)

Run No. Car Rater Date

1.0 0-20 50% TH
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

1.1 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-20 MD TH
H S B
E T S K A D
S M G F C C

1.2 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-20 MD TH
H S B
E T S K A D
S M G F C C

1.3 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-20 MD TH
H S B
E T S K A D
S M G F C C

1.4 70% TH
H S B
E T S K A D
S M G F C C

1.5 Idle Dr.
5 sec.
Ruf Stls

Idle Dr.
30 sec.
Ruf Stls

Turn HVAC Off
At this Point
Everything off

HVAC Off

Idle Dr
15 sec.

NO RATING

1.5 0-20 50% TH
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

1.6 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-20 MD TH
H S B
E T S K A D
S M G F C C

1.7 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-20 MD TH
H S B
E T S K A D
S M G F C C

1.8 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-20 MD TH
H S B
E T S K A D
S M G F C C

1.9 70% TH
H S B
E T S K A D
S M G F C C

2.0 Idle Dr.
5 sec.
Ruf Stls

Idle Dr.
30 sec.
Ruf Stls

CRC Driveability Hybrid Data Sheet

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

Turn HVAC Off

Starting time, Sec.

Initial	Restart 1	Restart 2	Idle Park Ruf Stls	Idle Drive Ruf Stls

0.0 0-20 50% TH
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

0.1 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-20 MD TH
H S B
E T S K A D
S M G F C C

0.2 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-20 MD TH
H S B
E T S K A D
S M G F C C

0.3 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-20 MD TH
H S B
E T S K A D
S M G F C C

0.4 70% TH
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

Turn HVAC On
At this Point
Everything off

HVAC On

Idle Dr
15 sec.

NO RATING

0.5 0-20 50% TH
H S B
E T S K A D
S M G F C C

0-15 LT TH
H S B
E T S K A D
S M G F C C

0.6 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-20 MD TH
H S B
E T S K A D
S M G F C C

0.7 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-20 MD TH
H S B
E T S K A D
S M G F C C

0.8 0-15 LT TH
H S B
E T S K A D
S M G F C C

0-20 MD TH
H S B
E T S K A D
S M G F C C

0.9 70% TH
H S B
E T S K A D
S M G F C C

1.0 Idle Dr.
5 sec.
Ruf Stls

Idle Dr.
30 sec.
Ruf Stls

Turn HVAC Off
At this Point

HVAC Off

Idle Dr.
15 sec.

NO RATING

CRC Driveability Hybrid Data Sheet (Page 2)

Run No.

Car

Rater

Date

1.0 0-20 50% TH

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

0-15 LT TH

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

1.1 0-15 LT TH

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

0-20 MD TH

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

1.2 0-15 LT TH

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

0-20 MD TH

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

1.3 0-15 LT TH

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

0-20 MD TH

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

1.4 70% TH

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

1.5 Idle Dr.
5 sec.

Ruf Stls

Idle Dr.
30 sec.

Ruf Stls

Turn HVAC On
At this Point
Everything off

HVAC On

Idle Dr
15 sec.

NO RATING

1.5 0-20 50% TH

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

0-15 LT TH

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

1.6 0-15 LT TH

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

0-20 MD TH

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

1.7 0-15 LT TH

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

0-20 MD TH

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

1.8 0-15 LT TH

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

0-20 MD TH

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

1.9 70% TH

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

2.0 Idle Dr.
5 sec.

Ruf Stls

Idle Dr.
30 sec.

Ruf Stls

CRC Driveability Hybrid Data Sheet

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

Starting time, Sec.			Idle Park	Idle Drive
Initial	Restart 1	Restart 2	Ruf Stls	Ruf Stls

0.0 0-20 MD TH	0-20 MD	0.1 0-15 LT TH	0-15 LT TH	0.2 0-20 MD TH	0-20 MD
H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C

0.3 0-15 LT TH	0-15 LT TH	0.4 0-30 WOT	0.5 Idle Dr. 5 sec.	Idle Dr. 30 sec.
H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	Ruf Stls	Ruf Stls

0.5 0-20 MD TH	0-20 MD	0.6 0-15 LT TH	0-15 LT TH	0.7 0-20 MD TH	0-20 MD
H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C

0.8 0-15 LT TH	0-15 LT TH	0.9 0-30 WOT	1.0 Idle Dr. 5 sec.	Idle Dr. 30 sec.	**Turn HVAC Off At this Point** Everything off
H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	H S B E T S K A D S M G F C C	Ruf Stls	Ruf Stls	**HVAC Off**

CRC Driveability Hybrid Data Sheet (Page 2)

Run No. Car Rater Date

1.0 0-20 MD TH

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

0-20 MD

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

1.1 0-15 LT TH

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

0-15 LT TH

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

1.2 0-20 MD TH

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

0-20 MD

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

1.3 0-15 LT TH

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

0-15 LT TH

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

1.4 0-30 WOT

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

1.5 Idle Dr.
5 sec.

Ruf Stls

Idle Dr.
30 sec.

Ruf Stls

Hybrid Data Sheet

Car ______________ Rater ________________ Date______________

Maneuver	Starting State of charge	Driving Charging rate	Engine On/Off	Milli Volt Reading	Battery pack Temperature	Comments
Starting						
Idle Park						
Idle Drive						
0-15						
0-15						
0-20 WO						
0-15						
0-15						
10 – 20						
0 – 20						
Idle Drive						
0-15						
0-15						
0-20 WO						
0-15						
0-15						
10 – 20						
0 – 20						
Idle Drive						
0 – 45 Crowd						
25 –35 Detent						
Idle Drive						

Beginning of each maneuver write readings down

APPENDIX G

DEFUELING, FLUSHING, AND FUELING PROCEDURE

FUELING AND DEFUELING PROCEDURE

VEHICLE PREPARATION

Used test fuel from the vehicle is drained just before the fuel rail. The fuel line is disconnected at the OEM quick-disconnect to the fuel rail, and a Hansen fitting with hose is inserted between the fuel line and the fuel rail. During defueling, a tee is inserted between the two fittings, with one end of the tee leading to the “slop” fuel drum.

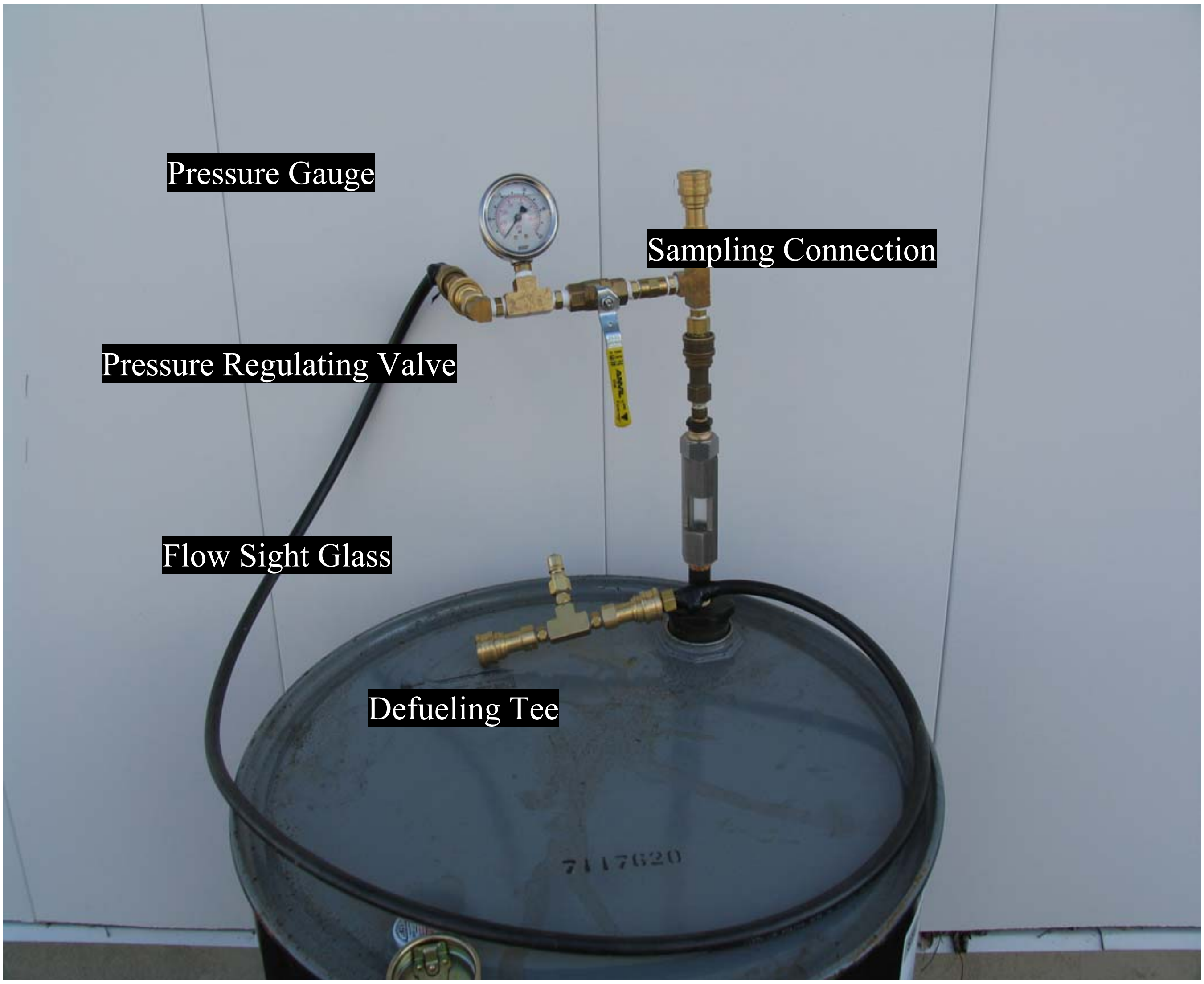
The next step in vehicle preparation is to install voltmeter leads to either the throttle-position-sensor (TPS) or the accelerator pedal, whichever is appropriate. The wires are routed into the passenger compartment of the vehicle to allow the rater to attach a voltmeter during testing. These wires should be long enough to allow either the rater or the observer to be able to read the voltmeter.

DEFUELING PROCEDURE

The fuel is drained into a “slop” drum. This draining system is a closed system, and requires the vehicle engine to be running during the draining procedure. The large bung of the “slop” drum is removed and replaced with a bung that has a two-foot stainless steel tube welded through it. The top of the tube has a Swedgelock fitting on it which attaches to a Hansen coupler. Atop the coupler is an apparatus which has a pressure gauge, a regulating valve, and a sight glass, along with an extra Hansen fitting to obtain fuel samples. During defueling, this apparatus is connected to the vehicle’s fuel line via the tee inserted as described above.

The small bung of the drum is removed and replaced by a bung with a float arrangement fabricated to indicate when the drum is full. This float arrangement has corks mounted on a rod on the underside of the small bung and a flag mounted on the same rod on the top-side of the small bung. As the fuel level in the drum rises, it pushes the corks up, which in turn pushes the flag up. This notifies the defueling personnel that the drum is full and must be changed.

Following is the procedure for draining and flushing the fuel system:


Pressure Gauge
Sampling Connection
Pressure Regulating Valve
Flow Sight Glass
Defueling Tee
7117620

FUEL TANK FLUSHING PROCEDURE

Precautionary notes:

1. ***When draining the vehicle fuel tank, the vehicle engine is running, and the pressure to keep the engine running is regulated at the "slop" drum.***
2. ***Some vehicles require that the accelerator pedal be depressed to keep the engine running. An adjustable rod may be used to do this.***
3. ***Use a UL approved ground strap to ground defueling equipment to the fuel injector rail or fuel line fitting for all fuel draining.***

Flushing Procedure:

1. When a vehicle comes in from testing, the defueling apparatus is connected to the vehicle, and the engine is started so the fuel will flow. The flow to the "slop" drum is controlled by the regulating valve.

2. If a fuel sample is required, allow fuel to be drained for one minute through the draining apparatus on the "slop" drum before taking a fuel sample. Fuel from the vehicle should also be drained through the sampling line to ensure that the sample is not contaminated. A sample can then be taken from the sampling port on the draining apparatus.

3. Completely drain the vehicle's fuel tank, at which time the engine will shut down.

4. Remove the fill cap, add four gallons of the next test fuel to the vehicle fuel tank, and replace the fill cap.

5. Start and idle the vehicle for a total of 2 minutes.

6. Completely drain the fuel tank through the draining apparatus, at which time the engine will shut down.

7. Remove the fill cap, add four gallons of the next test fuel to the vehicle fuel tank, and replace the fill cap.

8. Start and idle the vehicle for a total of 2 minutes. From approximately 15 seconds into the idle for a period of 30 seconds, rock the rear end of the vehicle from side to side. This task will require one person on each side of the vehicle.

9. Completely drain the fuel tank through the draining apparatus, at which time the engine will shut down.

10. When the vehicle is ready, remove the fill cap, add four or five gallons as required of the test fuel to the vehicle fuel tank, and replace the fill cap.

FUELING PROCEDURE

The vehicles are fueled out of a 55-gallon drum of test fuel, using a portable dispensing pump. This dispensing pump has been fabricated by mounting the motor and gauge on a hand-truck. The dispensing pump is service station quality. The large bung of the drum is removed, and a steel pipe is inserted into the drum. The top of the pipe has the male side of the Hansen coupler on it and is connected to the female side of the coupler on the dispensing pump inlet hose. The small bung is loosened just enough to keep the drum from collapsing while fuel is being pumped out of it.

Ground straps are used throughout the fueling and defueling process to avoid static electricity.