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**New Technology Research & Development Program  
Grant Contract 582-5-70807-T040**

**Test Plan Deliverable Report**

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May 31, 2005

**TO:** Clean Diesel Technologies, Inc.  
300 Atlantic St.  
Suite 702  
Stamford, CT 06901-3522

**ATTN:** Mr. James M. Valentine

**SUBJECT:** SwRI Preproposal EVR-5274 entitled "TCEQ Alternative Diesel Fuel Certification Program for Clean Diesel Technologies, Inc."

## 1.0. INTRODUCTION

The Department of Engine and Emissions Research (DEER) at Southwest Research Institute® (SwRI®) is pleased to provide this preproposal to Clean Diesel Technologies, Inc. for emissions testing of a candidate fuel using a protocol specified by the Texas Commission on Environmental Quality (TCEQ) Chapter 114 – Control of Air Pollution From Motor Vehicles, Subchapter H: Low Emission Fuels, Division 2: Low Emission Diesel. The protocol is based on transient emission measurement procedures developed by the EPA for emissions regulatory purposes. The TCEQ protocol allows a 1995 Navistar DT-466 to be used as the "test bench" for comparing engine emissions using a reference fuel, "Fuel R," and your candidate fuel, "Fuel C," if this engine is approved by the executive director as being equally representative of the post-1990 model year heavy-duty diesel engine fleet. The TCEQ protocol requires that fuel evaluations be conducted using one of five "alternative" test sequences that involve utilizing either cold- and hot-start transient test sequences or hot-start transient test sequences alone.

## 2.0 STATEMENT OF WORK

SwRI proposes to test a reference fuel, Fuel R, that meets TCEQ specifications and your candidate fuel, Fuel C, using the TCEQ §114.314 "Approved Test Methods." This TCEQ procedure

*This preproposal is submitted as a guide and merely represents our estimated time and price to perform the services based upon our general understanding of the program and your needs at this time. The estimated time and price as set forth herein are subject to change. This preproposal shall not constitute an offer for services and is intended for discussion purposes only. Should your company decide to have SwRI conduct this program, SwRI would prepare a formal proposal which would include a statement of work and contract for services.*



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has been transformed into a test procedure for the purposes of this preproposal. The first step in the process is to show that the candidate fuel meets the requirements of the American Society of Testing and Materials (ASTM) D975. For the purpose of this preproposal, it has been assumed that these requirements will be met by Clean Diesel Technologies, Inc. prior to initiating a test program at SwRI. If not, SwRI can provide these measurements at additional cost.

SwRI proposes to use "Alternative 4" of the TCEQ procedure (four other test sequences are allowed by TCEQ). "Alternative 4" calls for the test sequence to include six hot-start tests with the reference fuel, a conditioning period not to exceed 72 hours of engine operation with the candidate fuel, six hot-start tests with the candidate fuel, and a final set of two hot-starts with the reference fuel to show any residual affects of the candidate fuel when the additive is not included. Each average for a selected emission from a triplicate series of individual tests (i.e., RRR or CCC) is considered to be a single emission value for that fuel, to be used in statistically comparing the two fuels.

Emissions to be determined on each fuel include total hydrocarbons (THC), non-methane hydrocarbons (NMHC), carbon monoxide (CO), oxides of nitrogen (NO<sub>x</sub>), carbon dioxide (CO<sub>2</sub>), and total particulate matter (PM). The procedure given in Table 1 incorporates plans for instrument and sample system calibrations, changing fuels, determining engine performance, preparing and stabilizing emission measurement systems, and performing the transient test work to obtain the exhaust samples needed. Table 2 illustrates the pattern of hot-start transient runs to be made on Fuel R and on Fuel C. On each of the runs, THC, NMHC, CO, NO<sub>x</sub>, PM, and CO<sub>2</sub> will be determined. Hot-start transient emission tests will be conducted as specified in the Code of Federal Regulations (CFR) Title 40, Part 86, Subpart N. Procedures for the measurement of THC, CO, NO<sub>x</sub>, CO<sub>2</sub> and PM are described in Subpart N.

The test procedure outlined in Table 2 will require an estimated minimum of six days and will also require an estimated minimum of 225 gallons of Fuel C. In the event that repeat testing is required, it is important that additional quantities of test fuels be made available. In addition, emission measurement problems or engine problems can occur, requiring diagnostic efforts which generally can be run on in-house fuel; however, additional quantities of test fuel (20 gallons) should be allocated to ensure that there is enough fuel for an extra fuel change and emission run, if needed.

### **3.0 SCHEDULING, REPORTING, AND PRICE**

SwRI will attempt to test your fuel in a timely manner. After test preparations are completed, it is planned that the emissions test work outlined in Table 1 will be conducted using extended hours over a normal 5-day work week. Clean Diesel Technologies, Inc. will be notified if delays within the normal work period exceed 48 hours.

It is recognized that the combination of emission measurement capabilities and a unique engine can potentially create many problems in scheduling emissions testing of various fuels. Scheduling fuel testing will be at the discretion of SwRI. We will strive to maintain a reasonable balance of emission data generation for all potential sponsors of this work.

**TABLE 1. PROPOSED PROCEDURE FOR ACCUMULATING REGULATED EMISSIONS DATA USING ALTERNATIVE 3 OF THE TCEQ PROTOCOL**

Step	Description
1	Install engine. Perform emission instrument calibrations as required. Calibrate torquemeter and check signal conditioning systems. Validate CVS gaseous and particulate sampling systems using propane recovery techniques.
2	Check engine condition using in-house, low sulfur emissions type fuel, and note fault codes if any. Bring engine oil level to "full" using REO-216 oil.
3	Perform fuel change procedure to operate on Fuel R. Change filter, purge fuel supply, etc.
4	Warm up engine and operate at rated speed and load, then check performance.
5	Conduct transient "full-throttle" torque map from low- to high-idle. Compute and store resulting transient command cycle. (Note: <u>This initial transient command cycle with Fuel R will be used for all subsequent emission tests in this test plan. Other torque-map information generated with either Fuels R or C during this test work will be stored for documentation purposes.</u> )
6	Run two 20-minute practice or conditioning transient cycles without a 20-minute soak between cycles, and adjust dynamometer controls to meet statistical limits for transient cycle operation
7	Soak the engine for 20-minutes. Run six hot-start transient tests with a 20-minute soak between each. For each individual hot-start test, determine THC, NMHC, CO, NO <sub>x</sub> , and PM
8	Perform fuel change to Fuel C. Operate the engine for up to 72 hours using a cycle to represent normal engine operation.
9	Repeat Steps 4 through 7.
10	Perform fuel change to Fuel R. Repeat Steps 4 through 6.
11	Soak the engine for 20 minutes. Run two hot-start transient tests with a 20-minute soak between each. For each individual hot-start test, determine THC, NMHC, CO, NO <sub>x</sub> , and PM.
12	Summarize data and prepare the final report.

The price for one evaluation using the TCEQ protocol outlined in Table 1 is \$26,500. This price includes 14 hot-starts ideally run over several working days, for which 14 determinations of THC, NMHC, CO, NO<sub>x</sub>, PM, and CO<sub>2</sub> will be made. This price does not include engine installation because it is assumed that the engine will already be in the test cell nor for any engine operation in Step 8 in Table 1 which is currently undefined and will be billed as an additional item at a price of \$120 per hour. An additional fuel evaluation (six additional hot-starts with a second candidate fuel

**TABLE 2. PATTERN OF RUNS USING "ALTERNATIVE 4"**

Test Day	Hot Start Transient							
	Fuel	Test Number			Fuel	Test Number		
1	R	1	2	3	R	4	5	6
Engine operation for not to exceed 72 horus								
5	C	7	8	9	C	10	11	12
6	R	13	14					

followed by two hot-starts with the reference fuel) can be performed for a price of \$10,150 assuming that the engine is still installed in the test cell, the initial baseline can be used for the second fuel, and no additional durability is required. Additional tests will only be run if authorized by an appropriate representative of Clean Diesel Technologies, Inc. in writing. This documentation will be used as a basis for additional charges to Clean Diesel Technologies, Inc. Reporting will be limited to a report briefly describing the emission test results obtained on the fuels in sufficient detail for use in TCEQ application. Supporting documentation for the emission testing will be retained by SwRI for up to three years.

The reference fuel to be used in this program will be supplied by SwRI, and the candidate fuel will be supplied by Clean Diesel Technologies, Inc. Information on hydrogen, carbon, oxygen, and sulfur content (including any other elements present in significant amounts) for each fuel will be performed by SwRI to enable calculation of emission results. No additional fuel analyses and/or fuel blending are anticipated in this program unless these measurements are required by Clean Diesel Technologies Inc. In that event, the cost for these analyses will be included in the final price.

#### 4.0 SUMMARY

SwRI has attempted to address the needs for conducting a test program to obtain transient emissions data using a reference fuel, Fuel R, and your candidate fuel, Fuel C. The emissions data are to be accumulated using the procedure outlined in Table 1 to conduct the emission tests and fuel changes. The emission results for the candidate fuel will be compared to the emissions results for the reference fuel by applying the applicable TCEQ-specified statistical procedure. Should any changes or additional information be required prior to Clean Diesel Technologies, Inc.'s approval of this proposed effort, please feel free to contact E. Robert Fanick at (210) 522-2653. This preproposal should be presented to the TCEQ executive director prior to beginning the tests.

It has been a pleasure to prepare this letter preproposal. We hope the items and approach discussed will meet your needs. The DEER at SwRI looks forward to beginning this project as soon as possible. If you have any questions of a technical nature, please contact E. Robert Fanick by telephone at (210) 522-2653, by FAX at (210) 522-3950, or by e-mail at [RFanick@swri.edu](mailto:RFanick@swri.edu). Questions of a contractual nature should be addressed to Ms. Sherry Twilligear at (210) 522-3948 or

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