

# Fuel Research Using the Internal Diesel Injector Deposit (IDID) Rig CRC DP-04-17

CRC Response to the Questions by Potential Contractors

June 2017

**Question: Part Number for the Required Delphi Injector: The RFP says we need to use the same Delphi injector type for all tests but it does not provide a specific Item number. We need to know the specific ID for injector that is supposed to be used for this program. By our count we will need 80 of them and a seemingly minor difference in price can add up fast.**

Answer: The original injector used was “EJBR04001D”. Let Dr. Lacey know if you have an issue locating this and he will do his best to assist.

**Questions: Does the injector system require pressure control by inlet meter at the pump or outlet meter at the rail? One could surmise from the Delphi information that outlet pressure control was the desired approach but that is not clearly stated.**

Answer: Pressure control was via the rail.

**Question: Is there any written method for the work David Abdallah provided? It is not in the final report presentation, referenced below. All that shows is the data summary of the work he did.**

Answer: David Abdallah is the expert and provided the following notes:

I don't have a method. As I have said, VASE requires a solid background in robotics (stage recipe editing), spectroscopy (exposure recipe editing), optics (modeling of the ellipsometry data). It is not amenable to a single method and you must adjust according to sample geometry, deposit types, modeling preferences. Covering all that would be a massive effort. If someone is asking for a method, they are not ready to undertake such a task. I plan to write an overly-simplistic explanation of a VASE analysis for an IASH paper but that will not be available until late summer. Hence the reason I said I'll be happy to help or point the person to others that can help. I will not leave you hanging and I will make sure it gets done and reviewed by experts.

A quick account of what needs to be done for just the “modeling of the ellipsometry data” would include optical characterization of the metal substrate first using clean unused parts and optical properties modeled using either a B-Spline oscillator or parameter fitting an existing model for the same metal to accommodate for the differences. Not having clean parts from the 4 injector from the CRC study I made stuff up based on experience. Deposit characterization was done using a mainly Gaussian or Lorentz type oscillators in the deposit models (there are many and you need to adjust to what you see in the ellipsometer data accordingly) from a position where the deposit was around 100 nm thick, if not available the thickest deposit position was used. After parameter

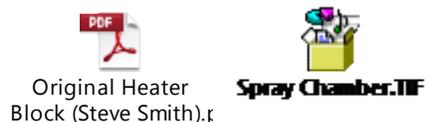
fitting of the deposit optical model the parameters were frozen and only the thickness was allowed to fit for the remaining points in the scan. In some cases, the fits are not always good throughout the scan and a judgment call is needed on how to change the models to best cover all the data. In some cases, the ellipsometric data is too complex to be modeled using the simple single layer approach that I've described above. More advanced modeling can be done but it means that more than just thickness is varying which causes thickness mapping to be misleading. For examples, some areas are thick but lower density while others area are thin and higher density which mean the amount of deposit contained in a thickness measurement will be highly misleading and reporting the amount of material is more important than thickness. There are more examples that I won't go into. In cases were the deposits are highly uneven within the beam area, or rough, blotchy, heterogeneous morphology (which scatters lights) the reflected light was insufficient so no thickness measurement can be made.

Measurements on deposit with the ordinary lacquer appearance is the most straightforward and reliable. Deposits areas that are dull and give a diffuse light appearance tend to be more problematic.

Just to be clear, VASE will not work on some of the internal injector deposits the rig will generate in the CRC project. I'm certain of this. All the blotchy white deposits (which stems from salt additives/contaminates) can't be measured and you have to stick with visual. Considering there is no solid connection between the VASE measurements and the past CRC engine studies the primary evaluation should remain the same as that which was used in the past to develop the correlations (visual ratings between all types of deposits) to includes the deposits that can't be measured by VASE. In addition, the very small subset of injectors I looked at (4 highly handled needles from 4 completely different injector types; 2 Delphi needles from 2 different types of injectors, 1 John Deere and 1 Cummins injector, in some cases the appearance of the part didn't match to what I observed in the CRC reports which suggests they got mixed up before I received them) is far too insufficient to change the evaluation methodology in the new proposal. However, VASE should be included as a means of supplying additional supporting data, not the primary means of deposit evaluations.

**Question: Could you ask if a legible version of the drawing in Appendix A of Delphi procedure is available. I cannot make out most of the dimensions.**

Answer: Two drawings attached as follows:



There is nothing especially significant about the design beyond the fact that the injector needs to be a good fit and the bores for the heater cartridges need to have appropriate clearances for the design used. Of course, all current local safety requirements need to be met, such as temperature control and pressure relief etc. In the end the block is nothing more than a means to electrically

heat the body of the injector in a controlled manner. It must also contain and dispose of the injected fuel safely.

**Questions: From the presentation made by David Abdallah, we infer the intended analysis target is the needle. However, there is also data for Delphi nozzles, with mixed results. Are we expected to do the both the needle and the nozzle or just the former?**

Answer: This project is focused on internal injector sticking, and not conventional nozzle hole carbonaceous deposits. Relevant parts to the internal diesel injector deposit (IDID) should be considered.