Hot Start Problem caused by Fuel Vaporization on Rover SD1 Efi Systems

Since 1996 I have been intrigued by this subject making several attempts to understand why it occurs and how Rover formally resolved it. In 2006, Campbell Macrae found an '86 Technical Newsletter that Rover sent to its Australian Dealers which throws new light on the subject. The following front page defines Rover's problem and their solution:

***Problem**: Fuel vaporization can occur at the injectors when a vehicle with the engine at warm to hot operating temperature is parked in the sun for a short period and then restarted. Should a customer complaint of this nature be experienced, the following action should be taken.*

***Solution**: Provision has been made for the fuel pressure to be increased temporarily during engine starting and for a short period of operation after engine start-up. As this effect would be undesirable if it occurred at every engine starting cycle, provision has also been made for it to only apply when the engine is at a high operating temperature.*

The modification is accomplished by means of a solenoid valve installed after the fuel pressure regulator valve, to restrict the fuel return for up to 45 seconds after starting is initiated. This enables purging of the fuel system. At the same time, the fuel pump ballast resistor is by-passed, thus supplying direct battery voltage to the pump with consequent increased output. Over- riding temperature control is achieved by use of the switch which activates the electric engine cooling booster fans.

***Note**: First ensure that the engine fuel and electrical systems are to standard specification and the engine is in good tune.*

***Range of Vehicles**: All electronic fuel injected models. Dated January 13 1986*

During the 1986 time-frame a similar bulletin was issued to U.K. Dealers but apart from a list of items found on the micro-fiche, no copy of the UK document has been found.

In both cases Rover provided a "Hot Start Kit" for Dealers to fit to customer's cars when complaints were received. The U.K. and Australian Kits were slightly different, as were the wiring loom changes for both regions, unfortunately, for the time being, neither of the supplementary circuit diagrams have yet been discovered, making direct comparison somewhat difficult. However, a comparison of kit components clearly indicates that the U.K. and Oz solutions were essentially the same, in that they both used the same four additional active circuit components shown below but the Oz kit also included a made up wiring harness whereas the UK kit did not.

The UK "Hot Start Kit" is specified on SD1 microfishe No.3 G03, under part number BHM 1620 and originally retailed at about £140. The four active components (not including brackets,hoses, clips, relay sockets, wire, etc) are:

AUU 1028: Solenoid valve. DRC 1820: Relay (2 off). AUU 1029: Delay relay.

Thus it has been possible to establish, from the Oz document, that by a combination of switched relays, a delay unit and a solenoid valve, the fuel pressure was temporarily increased, when the engine was too hot, thereby purging the fuel system and enabling the engine to re-start.

Bear in mind, whatever solution Rover devised, it had to work seamlessly from the ignition key. A mickey-mouse fix such as those mentioned later on would not satisfy indignant owners who suffered this hot start problem every time the sun shone on their executive car just a two or three years after they purchased it. Not good PR methinks?

Twenty years later

So what is going on here? Well in 2006 a forum question arose from a non-SD1 source regarding fuel vaporization and how it can prevent Rover V8 Efi engines from re-starting when they are hot, often when retro-fitted to cars with smaller engine bay dimensions. The same question has also arisen from time to time on SD1 forums and discussion groups with regard to original SD1 Efi installations. Clearly, all these years later, the intriguing problem still exists.

My interpretation is that our Efi systems can and do suffer from fuel vaporization, all the more so if there is restricted under bonnet clearance. Think about it this way. When the engine stops, all the latent heat in the block is no longer able to be removed by the cooling system and the block temperature is very high, more especially in hot weather.

Now, with the car stationary and the cooling process inactive, that latent heat quickly rises and is collected by all the metal parts surrounding the fuel intake system, including the plenum and the fuel rail. This area gets very much hotter a few minutes after stopping than it ever does under normal running and cooling conditions.

This leads to the fuel vaporizing in the fuel rail and upon re-start, despite the pressure being controlled by the regulator, vapor is an expanded form of liquid, so the resultant air/fuel mixture will be much weaker than the anticipated stoichiometric ratio of 14.7:1.

Obviously when trying to re-start the car, the pump pushes in new, cooler fuel but it is still very hot under the bonnet and new fuel may still vaporize until it can carry some of that latent heat away. A difficult task if you think about it. From our school physics lessons we learned the amount of heat required to vaporize a liquid is many times more than required to raise its temperature by just 1 degree (i.e. 1 calorie will raise 1 cc of water by 1 deg C, but it takes 540 cals to vaporize the same amount into steam at normal pressure. It’s less for petrol but still significant at about 80 cals depending upon pressure).

With fairly limited fuel flow all that trapped heat is not going anywhere until perhaps, in desperation, we lift the bonnet, peer suspiciously at the engine, pull at a few wires, suck our teeth and generally curse our luck for a few minutes. All this while the heat is at last escaping to the atmosphere very nicely thank you. After a few minutes the vaporization is

reduced and, bingo, the engine starts. Relieved to be mobile again off we drive, until it happens again the next time we stop and the mystery continues to confound us.

As far as one can tell, there are few, if any, SD1's on the road today with a retro-fitted "Kit" in place and with no circuit diagrams available to enable better understanding of Rover's solution, how might we currently deal with the problem if it occurs?

- Lift the bonnet and wait.

- Give the accelerator some heavy boots-full when re-starting to make the fuel flow faster and give a richer mixture.

- Run the fuel pump for a few minutes without starting the engine. This can be done on both auto and manual SD1's. On an auto try to crank the engine in drive, the pump runs but the engine does not turn. On a manual, disconnect the engine harness and try to crank the engine, the pump runs but the engine does not turn.

- One can't very well relocate the fuel rail but it might be possible to lag it - but thinking about that, it would probably work against the problem when everything is piping hot!

- Fit thermostatic electric cooling fans that continue to run after the engine has stopped to try and remove latent heat from the engine whilst the car is stationary. However, with no circulating coolant this would be a marginal solution.

The Underlying Problem

The Rover SD1 system should be able to cope with this condition but it sometimes does not - Why? Well one issue is that Rover put a large blanket under the SD1 bonnet as a noise insulator, it perversely also acts as a heat insulator yet the cars, as originally sold from 1982 through 1985, did not unduly suffer this problem.

Only after some years, from new, when these problems became manifest did Rover design and issue the after-sale, dealer fitted, Hot Start Kits to solve the problem.

I believe the main reason the problem occurred after a few years service is because the Efi system is probably not functioning correctly in other areas such as mixture, set-up, air leaks, electrical connection problems, component faults, etc. i.e. poor maintenance of the system in general (not surprising, as anyone who used franchised dealers for servicing will know, even today). When this happens it makes it more difficult to cope with the fuel vaporization abnormality.

The real answer would be to check the system out thoroughly along with the electrical connections. Whilst it is entirely possible to solve inherent problems using a scattergun approach, in the end a thorough analysis of the system is the best route to follow which can be achieved using clear guidelines, simple instruments and boring techniques.

Rover Hot Start Kits

So what is known about the hot start kits and how did Rover intend they should actually work? Despite the lack of circuit diagrams the basic principle seems to be as follows.

As already seen from the Australian bulletin, Rover's idea was to temporarily raise the pressure at the injectors by blocking the fuel return pipe using an electrically operated solenoid. The revised system also bypassed the fuel pump ballast resistor to maximize that effect. This brings to mind another of our school physics experiments to show that if the pressure of a liquid is raised so then is its boiling point. Thus, it stands to reason that, if the liquid has already vaporized (boiled) and the pressure is subsequently raised, the vapor is now likely to return to its liquid state and will behave once more as liquid.

With the pressure at the injectors raised to about 50 psi not only will the fuel try to re-liquidize, but the injectors, which normally operate at 28 to 36 psi, will pass between 40% and 80% more fuel each time they open, significantly enriching the mixture such that the engine should immediately fire and run.

Then there is the question of how the system "knows" when to operate. The inclusion of a radiator temperature sensor in the circuit means that the engine has to be very hot before the high fuel pressure function is triggered, and of course the engine must be cranking, so it is reasonable to assume that as soon as the engine fires and cranking ceases, the system is deactivated and the fuel pressure immediately returns to normal.

Clearly, Rover decided it was undesirable to over-pressurize the system too frequently, restricting it to occur only when the engine was very hot. Even so, they were confident the system could withstand the 50 psi designed into the solution without causing fuel leaks or damage to components such as the pressure regulator, pump and fuel lines.

Summary

So there it is! The myth of fuel vaporization (sometimes called vapor lock) clearly does exist on the SD1 Efi and whilst Rover devised a method of dealing with it, the circuit diagrams have not emerged in the intervening years. However the Australian Technical Bulletin has materialized and it contains all the information regarding components, part numbers and specific changes to the wiring loom so any enterprising home mechanic could carry out the modifications and solve the problem the "Rover Way".

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