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Understanding the Impact of Engine Misfire on Air/Fuel Ratio Control System and Control Valve Performance

While the basic troubleshooting requirements associated with the operation of the EPC-100-series products are well-documented in the system literature, it is important for all operators to understand the significant impact that engine-related operating conditions have upon performance and control capability of the controller and the associated control valves. Fully appreciating the impact of engine misfire on air/fuel ratio control system performance is particularly critical as a misdiagnosis can often result in the unnecessary replacement of control system components, and ultimately the continuation of improper engine operation.

When an engine is operating normally and the EPC is in control, the stepper motor control valve regulating the flow of fuel between the fuel regulator and the carburetor should be operating within a band of 100-200 steps based upon a relatively steady signal from the lambda sensor monitoring the exhaust (0.4-0.9 Volts). The introduction of engine misfire – specifically that driven by ignition related issues such as excessive spark plug wear or fouling – dramatically upsets the operation of any air/fuel ratio control system (including the EPC) as the lambda sensor begins to detect the excess oxygen in the exhaust from the unburned air/fuel charge. In an effort to correct for this abundance of oxygen, the controller (believing that the mixture is too lean) instructs the control valve to open so as to attempt to bring the monitored lambda value back to the setpoint.

Unfortunately, the misfire event is causing the lambda sensor to lie to the controller regarding the real engine air/fuel ratio.

During a heavy misfire event, the controller will continue to see oxygen pockets from the unburned air/fuel charge and will attempt to open the valve in an effort to correct for what it believes to be a lean mixture. It will attempt to correct to the point where the valve is fully open and the controller eventually annunciates that it is at the “Rich Limit” level.

It is at this point that a troubleshooting error can be easily made. Many times, these conditions are attributed to a defective or “stuck” control valve as essentially any manual adjustment of the stepper motor position appears to have no effect on the valve coming from the lambda sensor. At that point, the stepper is often declared to be failed and replaced. If no corrective action is taken to resolve the cause of the misfire (or if some other condition changes on the engine), however, the EPC will eventually direct the replacement valve to the full open position in an effort to resolve what it continues to believe to be an overly lean AFR mixture. It is also true that if the misfire has been resolved that the controller will sense what is now an overly rich mixture (now that the excess oxygen has been removed) and will attempt to lean the mixture out by further restricting the fuel flow. Thus, if the valve is really “stuck” in the open position, the controller will quickly report a “lean limit” condition.

As with virtually any control valve, physical damage or contamination can cause irregular operation. The Altronic stepper motor control valves are no exception. Contamination by thick or corrosive liquids, poor or mis-wired connections, insufficient control valve operating voltage, and extended operation at the fully open or fully closed position may damage the valve to the point of non-responsiveness. Altronic is working continuously to limit the vulnerability of the stepper motor control valves to these external forces – including the recent release of a modified control valve-piston assembly that offers superior durability during extended full open or full-closed events.

HOWEVER, the likelihood and confirmed frequency of such occurrences where the valve is physically incapable of responding are extremely low, particularly for engines that are well-maintained and operated. In the vast majority of cases, it is neither the controller nor the valve that is responsible for an "at limit condition" but instead is the nature of the exhaust contents themselves being presented to the lambda sensor that is prompting some corrective action on the part of the controller. In the case outlined above, the sensor as being "fooled" by the excess oxygen in the unburned AFR charge from misfiring cylinders that caused an errant corrective action to take place and ultimately the diagnostic that the control valve was no longer responsive.

There is one additional item that needs to be understood in the operation of any air/fuel ratio control system – including the EPC. Beyond wiring or voltage delivery issues, it is only during periods where the engine is operating well out of its normal AFR band that the valves would ever be operating at the full open or full closed positions. Detection of either of those conditions should always prompt a fuller analysis of the engine for misfire or other combustion issues.