Summary

Zircotec's ThermoHold™ ceramic thermal barrier coating was shown to reduce manifold surface temperatures by more than 30% during independent testing. Within the specified range of test conditions, the Zircotec manifold displayed surface temperature reductions of up to 173°C. In addition the coating reduced convective heat transfer by 29.8%.

Test Objective

An internationally renowned, independent testing organisation was commissioned to compare the thermal insulation performance of a gasoline exhaust manifold with and without the Zircotec ThermoHold™ ceramic thermal barrier coating. Testing was performed to determine heat transfer rate, surface temperatures, and exhaust gas temperatures. The effect of different surfaces finishes was also investigated by testing both the original 'rough' and a 'smooth' coating.

Test Comparison

A Range Rover V8 gasoline engine was used on an engine test cell incorporating dynamometer, instrumentation, and data acquisition. Two new exhaust manifolds were procured and instrumented with K-Type thermocouples in an identical way to enable measurement of gas temperatures and boundary layer surface temperatures. One of the manifolds was coated with Zircotec ThermoHold, ceramic thermal barrier coating.

An exhaust manifold encapsulation was fabricated with air entry and exit orifices instrumented for inlet and exit temperature measurement by PRT (Platinum Resistance Thermometer). Two mass airflow rates through the encapsulation (i.e. over the manifold) were estimated that corresponded nominally to vehicle speeds of 35 MPH (225 kghr-1) and 70 MPH (450 kghr-1) respectively.

The dynamometer controller was programmed to follow a 10-site steady state sequence with an initial warm up at the first site of 15 minutes (3,500 RPM, full load). The 10 sites comprised loads of 100%, 80%, 60%, 40%, and 20% at speeds of respectively 3500 RPM and 2500 RPM.

This test design ensured the two exhaust manifolds were tested in under bonnet simulation conditions at varying engine loads and cooling rates.

All tests were undertaken on both the 'rough' and 'smooth' coatings.

Test Results

The Zircotec coated engine exhaust manifold was found to reject significantly less heat to its surroundings under conditions of forced convection when compared to an identical but uncoated Baseline manifold.

Smoothing of the Zircotec coating resulted in a further significant reduction in heat rejection.

Within the specified range of test conditions, the Zircotec manifold reduced convective heat transfer by up to 26.7% for the original surface finish and 29.8% for the smoothed finish.

Manifold surface boundary layer temperatures were found to be significantly lower with the Zircotec manifolds when compared to the uncoated Baseline manifold.

Within the specified range of test conditions, the Zircotec manifold displayed surface temperature reductions of up to 136^{o}C (original finish) and 173^{o}C (smoothed finish) when compared to the uncoated Baseline manifold.

With reduced exhaust manifold heat transfer exhaust gas temperature will be expected to increase. The magnitude of this increase was found to be small and confined to the uncertainty limits of the thermocouple measurements

It is reasonable to infer that under bonnet temperatures will be reduced with the Zircotec manifold but it is not possible to quantify this reduction without performing in-vehicle tests.