MVFRI RESEARCH SUMMARY

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Underhood Temperature Measurements

Based on a contract with:
Biokinetics and Associates, Ltd.

Under normal vehicle operating conditions automotive fluids are well contained and do not pose a fire threat as they are not exposed to excessively hot surfaces. However, the risk of fire increases if the fluids are spilled, as is possible following a crash in which fluid lines or reservoirs may be damaged. Fire may result if the spilled fluids are exposed to sufficiently hot surfaces.

The testing reported here attempted to identify the range of underhood temperatures to which spilled fluids may be exposed [Fournier 2004]. This was done by directly measuring the temperature of hot underhood engine and exhaust components. Comparisons were then made to the auto ignition temperatures of various automotive fluids. The temperature measurements were conducted with the vehicles loaded to their rated capacity for driving on a level road as well as uphill.

The vehicle underhood temperatures were measured during three loading conditions that were achieved when the vehicle was stationary, driving on a level road and driving uphill. For both of the driving conditions the vehicles were loaded to the rated capacity indicated on the door sill and tested at several driving speeds. For the stationary tests the engine speed was selected as a multiple of the base engine idling speed expressed in revolutions per minute (rpm). All the testing was performed with a minimum ambient temperature of 22 ºC.

The results showed considerable variation in the maximum temperatures of different vehicles when operated under load. While driving uphill, the maximum temperature measured on the surface of the exhaust manifold varied from 241^{o}C for a minivan to 550^{o}C for a passenger car.

None of the vehicles, when idling, exhibited temperatures that exceeded the threshold levels for ignition of underhood fluids as reported by research at FM Global in a research paper for MVFRI [Tewarson 2005] and by research under the GM/DoT Settlement Agreement [Santrock 2002]. Only at elevated idle speeds did the component temperatures begin to exceed the temperatures necessary to ignite some of the fluids.

Depending on their speed during the level road tests, each vehicle exceeded the minimum temperature required for the auto ignition of some of the engine compartment fluids. The temperatures at a given measurement location typically increased with an increase in speed. However, the effects of convective cooling moderated the increases in temperatures and in some cases caused a drop in temperature.

The additional load imposed by driving uphill significantly raised the measured temperatures as is evident by the larger incident of critical temperatures being reached. Under these conditions, the highest underhood temperatures measured by the thermocouples reached the range required for the auto ignition of antifreeze and engine coolant.

Some concerns have been raised over the method of attaching the thermocouples to the exhaust system components as reported in the Biokinetics report [Fournier 2004]. The exhaust manifold temperatures showed a substantial rise after the engine had been shut down, suggesting that the measurement was incorrect. A follow-on research project was initiated to further examine this concern [Fournier 2006; Fournier 2007]. In the earlier project, the temperature was measured by thermocouples clamped to the manifold. The follow-on project used several attachment methods including brazing the thermocouple to the manifold. The brazed-on thermocouple recorded temperatures 75 C° to 175 C° higher than the clamped thermocouples. Furthermore, the temperature measurements from the brazed-on units decreased as soon as the engine stopped. The differences in peak temperatures measured by three different thermocouple attachment methods are summarized in the final report for the project [Fournier 2006; Fournier 2007]. Brazing the thermocouple bead to the manifold is the recommended attachment method.

The two thermocouples with thermal mass associated with their construction, namely the clamp-on and the welded-on probe thermocouple registered lower temperatures, due to the forced convective cooling acting on the thermocouple sheathing. These two thermocouples also exhibited a delay in response and exhibited a significant temperature increase after the vehicle engine was turned off. The delay in response was associated with the thermal mass of the thermocouple construction whereas, the measured increase in surface temperature was believed to be associated with the cessation of forced convective cooling acting on the thermocouples housing and where applicable on the clamp attachment method. Consequently, these types of thermocouples may not be appropriate for surface temperature measurements where forced convection or quickly changing temperatures may be experienced. If used, however, these thermocouples would provide lower estimates of the surface temperatures that are actually attained.

REFERENCES

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