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TECHNICAL NOTE
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VEHICLE ENGINE PERFORMANCE IN FOREST FIRE CONDITIONS

SUMMARY

It is critical that the engines of any vehicles used in the vicinity of a forest fire are able to provide reliable service in the conditions encountered near a fire. These vehicles can include the personal vehicles of forest staff and contractors, personnel transport vehicles and fire appliances. Survival or escape may depend on the ability of an engine to deliver sufficient power. When selecting vehicles, it is important that consideration is given to their performance in forest fire conditions. The results of a study of five engines support the view that diesel engines are shown to be more suitable than gasoline engines for firefighting activities because of the following reasons:

- In situations with high air temperatures and/or depleted oxygen, diesel engines suffer less power loss than petrol engines. Petrol engines may not run at all in some situations.
- Diesel is less volatile than petrol so vapour formation in the fuel line is less likely.

In high temperature conditions, it will often be impossible to start carburetted petrol engines. (Fuel injected petrol engines were not included in the study). The results of the study support the view that diesel engines should be used in firefighting vehicles in preference to carburetted petrol engines.

HOW FIRE CONDITIONS AFFECT ENGINE OPERATION

Engine systems are designed to operate in normal atmospheric conditions. The oxygen concentration (grams per litre) of air near a fire may be lowered by mixing with gases produced by the fire. At elevated temperatures, air density is reduced so the oxygen concentration can be reduced further. For correct operation, engines require fuel and oxygen to reach the engine in the correct proportions. If the air is less dense than usual or the oxygen concentration is reduced, engine power loss will occur. High temperature may also cause fuel to evaporate or form bubbles within the fuel system. Engines may experience power loss or may not run at all under these circumstances.

This technical note summarises the findings of research carried out at the University of New South Wales during which two petrol engines (spark ignition, Land-Rover 11A and Isuzu G161Z) and three diesel engines (compression ignition, Isuzu 4FB1, Perkins 4.165 and Cummins 6B) were tested in conditions which simulated those of a fire site.

EFFECTS ON FUEL SYSTEM OPERATION

"Vapour lock" occurs when high temperature causes vapour to form in the fuel line. Because this vapour is compressible, the fuel pump is unable to remove it. Fuel flow to the carburettor or injection system may be reduced or prevented.

"Foaming" is the formation of vapour bubbles which form in the fuel line and enter the float chamber of the carburettor. This may increase the pressure in the bowl and may force additional fuel through the jets causing an excessively rich mixture.

"Percolation" occurs when the fuel in the float chamber of a carburettor boils. This can be caused by a high ambient air temperature or heat being conducted from the engine. If the engine is stopped, this may result in the fuel in the bowl being burned away completely or an excessively rich mixture being fed into the induction system, making restarting difficult.

In the parts of fuel injection systems where the fuel is at high pressure, the likelihood of bubble formation or boiling is reduced.

Foaming and percolation occur only in petrol powered vehicles. Vapour lock is much less likely to occur in diesel than petrol powered vehicles because it is less volatile (that is, it remains a liquid at higher temperatures).

ENGINE POWER LOSS

The reduced concentration of oxygen in heated air causes enrichment of the fuel mixture and consequently the engine produces less power.

With intake air temperature at 100°C, power losses for all engine types were not significantly different.

With intake air temperature at 200°C, one petrol engine would not run and the other showed much greater power loss than the diesel engines.

With intake air depleted of oxygen, the petrol engines again suffered greater power loss than the diesel engines.

With the air surrounding the Isuzu petrol engine at 75°C, power loss was 15% at 2800 rpm and 75% at 1050 rpm. It would be difficult to avoid stalling a vehicle operating under these conditions. Restarting the engine was impossible when the carburettor temperature exceeded 70°C and the engine had been stopped for a few minutes. This test was repeated for the Isuzu diesel engine which operated smoothly over the speed range for engine compartment temperatures up to 150°C with no apparent problems.

CONCLUSIONS

The results of the study support the view that diesel engines should be used in firefighting vehicles in preference to carburetted petrol engines. The term "firefighting vehicles" should apply to all vehicles which may attend a fire, not just fire tenders.

REFERENCES

Carter, E. and Milton, B. (1994) : "Internal Combustion Engine Performance in the Fireground" Int. J. Wildland Fire 4 (2)

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