# Measurement of Piston Ring Pack Lubricant Residence Time in a Gasoline Engine using Laser Induced Fluorescence

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## 1. Introduction

There is an ever increasing demand on engine lubricant manufacturers, together with lubricant additive companies and OEMs, to improve vehicle fuel economy, efficiency and extend lubricant service intervals. This in turn is demanding a better understanding of the tribology of the lubricant in the piston ring pack. It has already been found that the lubricant within the piston ring pack is more degraded than that in the sump, mainly due to a combination of higher temperatures, fuel dilution [1,2] and interaction with combustion gases. It is therefore necessary to understand the flow of lubricant through the ring pack and the replenishment of the lubricant from the sump.

A novel method of using laser induced fluorescence (LIF) has been developed to monitor the flow of lubricant through the ring pack of a fired engine. The work has shown that the lubricant residence time in the piston ring pack is affected by engine speed, load and lubricant viscosity.

## 2. Experimental

A single cylinder Ricardo Hydra gasoline research engine was used for experimental analysis. The cylinder liner was instrumented with thermocouples and a small sapphire window, 2mm in diameter, at mid-stroke on the thrust plane to allow optical access for the LIF probe system. This allowed parallel and focused light to pass to and from the window via a fibre optic cable. The engine was equipped with separate lubricant supplies for the valvetrain and for the crankshaft bearings and piston assembly. The latter had two external lubricant sumps with one of the lubricants doped with fluorescent dye. A valve was used to switch the lubricant supply between the two sumps during engine operation. A monograde and mulitgrade lubricant of different kinematic viscosity ($v$) grades were tested at various engine speeds and loads, *Table 1*. The time taken between the sump switch and the fluorescence signal to stabilise was taken as the lubricant residence time.

*Table 1: Test oil kinematic viscosity specification.*

| | Monograde lubricant | Multigrade SAE 5W30 |
|---|---|---|
| $v$ @ 40 $^{o}$C (cSt) | 48.0 | 69.5 |
| $v$ @ 100 $^{o}$C (cSt) | 8.3 | 11.7 |

## 3. Results and Discussion

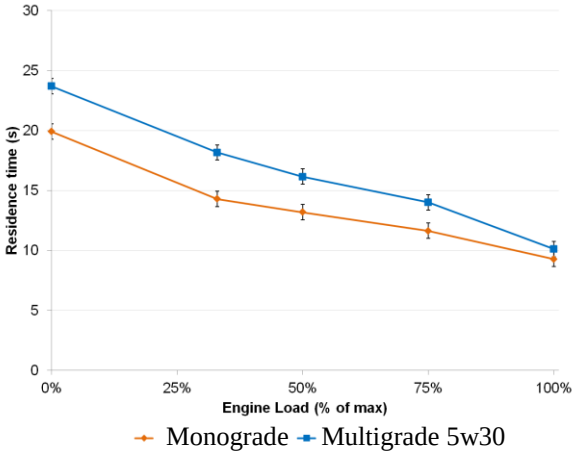


*Figure 1: Engine load effect on piston ring pack lubricant residence time.*

Experiments were performed at 1500 rpm with increasing engine load, *Figure 1*. It was found that increasing engine load reduced the lubricant residence time. The lower viscosity monograde lubricant will flow more easily through the ring pack and produces lower residence times than the multigrade lubricant, regardless of engine load. Previous research on this engine [3] measured the monograde lubricant residence time indirectly at 1500 rpm and 50% load on the same engine to be 60 seconds. Here a direct measurement time of approximately 13 seconds was recorded.

## 4. Conclusions

- An increase in engine speed reduces piston ring pack residence time.
- Replenishment was observed to be inversely proportional to lubricant viscosity. An increase in viscosity increased piston ring pack residence times.
- Increasing engine load reduced piston ring pack residence times.

## 5. References

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[3] Stark, M. S., et al. (2005). Tribology Letters. Vol. 19(3). Pages 163-168