Engine Oil Sulfated Ash and GPF Compatibility in Hybrid Vehicles

The role of formulation and operating conditions



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The role of formulation and operating conditions

Reducing engine oil sulfated ash (SASH) from 0.8% to 0.5% did not provide a quantifiable gasoline particulate filter (GPF) compatibility or durability advantage in this Afton Chemical study. The findings highlight the need to consider oil consumption, the complete lubricant formulation and vehicle operating conditions alongside nominal ash content.

Why this matters

Hybrid operation and tighter particulate emission requirements change the operating environment for both the lubricant and the aftertreatment system. For lubricant formulators and powertrain developers, a key question is whether lower SASH content necessarily improves GPF durability and emissions performance.

The study compared a mid-SAPS oil containing 0.8% SASH with an oil containing 0.5% SASH in a plug-in hybrid electric vehicle (PHEV) application. SAPS refers to sulfated ash, phosphorus and sulfur. The investigation considered how lubricant formulation, oil consumption, operating conditions and aftertreatment design interact.

Study design

- **Vehicle and aftertreatment**: a PHEV from a leading Chinese original equipment manufacturer (OEM), with a 1.5 L dedicated hybrid engine, a close-coupled three-way catalyst (TWC) and a GPF with filtration efficiency above 90%.
- **Test oils:** SAE 0W-20 GF-6/SP oils containing 0.8% and 0.5% SASH.
- **Vehicle field trial:** 80,000 km at normal ambient temperature, plus 20,000 km at extremely low ambient temperature, approximately -20 °C.
- **Measurements:** oil consumption and temperature, used-oil analysis, GPF weight and backpressure, aftertreatment temperature, gaseous emissions, particle number (PN), particulate mass (PM) and fuel consumption.
- **Durability evaluation:** burner-rig testing calibrated against field-trial ash loading and backpressure data extended the evaluation to an equivalent distance of 250,000 km.

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GPF compatibility and durability findings

The study reported no statistically significant differences between the two oils in ash accumulation in the GPF, GPF backpressure growth, gaseous and particulate emissions, or fuel consumption.

Emissions performance and backpressure

No significant difference in particulate or gaseous emissions was observed between the two oils throughout the vehicle field trial. Neither oil produced excessive backpressure growth; the 0.8% SASH oil showed a smaller increase during vehicle testing.

In burner-rig durability evaluations representing 250,000 km, particulate and gaseous emissions for both oils were below the proposed China 7 emission limits assessed in the study.

Ash loading depends on more than SASH content

Both oils showed similar ash loading rates in the field trial. The vehicle using the 0.5% SASH oil had higher oil consumption, illustrating why the lubricant's ash percentage alone does not determine the amount of ash reaching the GPF. SASH content and oil consumption should therefore be considered together when evaluating ash loading and backpressure growth.

At 80,000 km, GPF ash accumulation was approximately 4.34 g with 0.8% SASH oil and 4.33 g with 0.5% SASH oil.

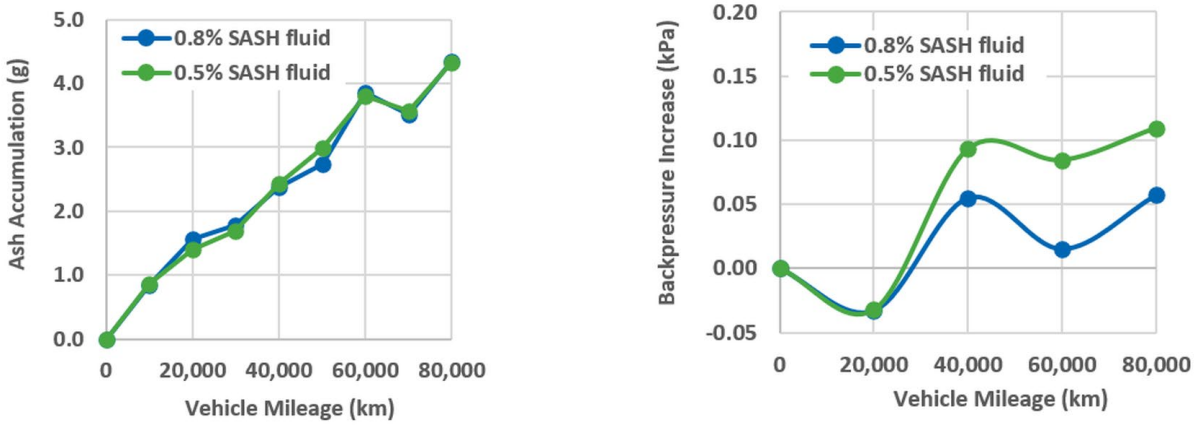


Figure 1. GPF ash accumulation and backpressure increase during the vehicle field trial. Backpressure was measured at a flow rate of 500 kg/h. Source: Afton Chemical study, August 2026.

Lubricant challenges in hybrid operation

The field trial also highlighted operating conditions that influence lubricant performance beyond nominal ash content. Drive cycle and ambient temperature affected engine operation, oil temperature, dilution, oil consumption and GPF ash accumulation.

Urban and highway operation

Table 1. Reported shares of drive time in the field trial.

Operating mode	Urban driving	Highway driving
Electric drive time	30.0%	8.1%
Engine drive time	64.9%	90.8%
Recuperation time	5.1%	1.1%

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Because the engine operates only when needed, hybrid operation can reduce engine-on time and create demand for longer oil-drain intervals. These service demands need to be considered alongside the dilution and temperature conditions observed in the field trial.

Extremely low ambient temperature

At approximately -20 °C, engine-on time increased by about 9 percentage points relative to normal-temperature operation in the mixed driving cycle, which used a city-to-highway ratio of 3:7. Average oil temperature was 64 °C, approximately 30 °C lower than during normal-temperature operation.

Average fuel dilution reported per 10,000 km increase for both oils under low-temperature conditions, as shown in Table 2.

Table 2. Average fuel dilution per 10,000 km, as reported in the study. Values are rounded to two decimal places.

Test oil	Normal temperature	Low temperature
0.8% SASH	2.5%	7.1%
0.5% SASH	2.6%	7.0%

During short urban trips with frequent hot-soak periods, water content reached 3% and fuel dilution reached 12%. Oil consumption and GPF ash accumulation were also higher during low-temperature operation than at normal temperature.

These findings highlight the need for hybrid lubricants to address aftertreatment compatibility, fuel dilution, low-temperature operation and extended service demands together.

Implications for lubricant and powertrain development

The results support evaluating SASH content as part of the complete lubricant and aftertreatment system in hybrid vehicles equipped with high-efficiency GPF technology.

Evaluate SASH content in context

No quantifiable disadvantage was found for the mid-SAPS 0.8% SASH oil compared with the 0.5% SASH oil in GPF compatibility and durability under the conditions tested. Lower nominal ash content alone did not demonstrate a performance advantage in this investigation.

Consider the complete formulation

Oil consumption and formulation behavior can influence the amount and effect of lubricant-derived material reaching the GPF. Evaluating these factors together provides a more complete basis for lubricant selection.

Validate under representative operating conditions

Drive cycle and ambient temperature materially affected engine-on time, oil temperature, dilution, oil consumption and ash accumulation in the field trial. Validation should reflect the operating conditions relevant to the intended vehicle application.

Use vehicle data to inform durability testing

The burner-rig methodology was calibrated using field-trial ash loading and backpressure data before extending the evaluation to an equivalent 250,000 km. This connected the durability assessment to the behavior observed in vehicle operation.

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Conclusion

In this investigation, the combination of a high-filtration-efficiency GPF, optimized catalyst design and mid-SAPS oil technology demonstrated robust hybrid-vehicle performance. The findings support selecting lubricants with a combined view of formulation, vehicle operation, aftertreatment design and driving cycle, rather than using SASH content alone as the deciding criterion.

About this white paper

This white paper summarizes the Afton Chemical presentation "Investigation of Lubricant Derived SASH Level Impact on Hybrid Vehicle Aftertreatment System Performance" (August 2026). Results are specific to the tested vehicles, oils, hardware and conditions and should not be interpreted as universal performance claims.

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