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Zinc-free vs Ashless:
Myth, Marketing or Meaning?

Beyond the terminology in hydraulic fluid technology.



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As sustainability becomes a greater priority across the lubricants industry, zinc-free and ashless hydraulic fluids are receiving increased attention. Although the two terms are often used interchangeably in product literature and market discussions, they represent distinct formulation approaches with important technical differences. Understanding those differences can help lubricant marketers, formulators, and end users make more informed decisions.

At the same time, hydraulic systems continue to evolve. Modern equipment is designed to deliver greater power density through higher operating pressures, more compact components that reduce weight and save space, and improved efficiency that lowers energy consumption and operating costs. Today's excavators, injection moulding machines, and industrial presses operate at pressures and speeds that would have been difficult to imagine just two decades ago.

As a result, hydraulic fluids must deliver exceptional durability, precise control, and reliable protection. Against this backdrop, the distinction between zinc-free and ashless technologies becomes increasingly relevant. While both can deliver high levels of performance, their formulation strategies differ in ways that can influence cleanliness, oxidation control, and application suitability.

By understanding the differences between zinc-free and ashless technologies, the industry can move beyond marketing terminology and focus on the performance characteristics that matter most in modern hydraulic systems.

Beyond the Label: Understanding Zinc-Free and Ashless Hydraulic Fluids

Removing zinc from hydraulic fluids isn't just a formulation choice; it signals a broader shift in how the industry defines "performance." Zinc-free and ashless demonstrate that high levels of anti-wear protection, corrosion defence, and system reliability can be achieved without relying on heavy metals.

This brings two distinct advantages. First, replacing zinc-based additives can contribute to a lower product carbon footprint, supporting manufacturers' wider sustainability goals. Second, eliminating heavy metals helps improve the environmental profile of the fluid, making these formulations particularly well suited to environmentally sensitive applications, such as forestry and agriculture, where accidental leaks into the surrounding environment are a concern.

ZINC-FREE	ASHLESS
✔ No zinc anti-wear additives	✔ No metallic additives
✔ May contain small amounts of calcium-based detergents	✔ No metallic detergents
✔ Very low sulphated ash	✔ Near-zero sulphates ash
✔ Provides detergency and acid neutralisation	✔ Maximum formulation purity

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Why a Little Detergent Goes a Long Way

Formulating a hydraulic additive package is fundamentally an exercise in managing tribological stress, thermal degradation pathways, and contaminant loading across a wide range of operating conditions. Each end user's equipment dictates a different balance of oxidative stability, cleanliness control, and wear protection. Within this formulation space, detergents serve as a critical functional component.

Detergents help manage deposit buildup in the oil, minimising sludge and varnish formation, ensuring system cleanliness for as long as possible.

In zinc-free hydraulic formulation, a small amount of detergent is necessary to fulfil a vital, secondary function: the neutralisation of acidic oxidation by-products.

In addition to deposit control, they have a secondary benefit of acting as a control mechanism for the chemical and physical stability of the entire hydraulic system, influencing wear rates, oxidation behaviour, and deposit formation to a far greater extent than their concentration alone might suggest.

As a result, zinc-free hydraulic fluids bring the opportunity of balancing performance and sustainability in demanding operating environments, particularly in applications such as mining machinery, agricultural and forestry equipment, and marine hydraulic systems.

Do OEMs differentiate between zinc-free and ashless?

Across the hydraulic industry, little to no differentiation is made between zinc-free and ashless technologies when defining performance requirements. The primary focus is on whether a fluid can successfully meet the requirements of a fluid specification or a manufacturer-specific approval such as Bosch Rexroth RDE 90245 or Parker HF-0.

OEM specifications typically evaluate a fluid's ability to provide wear protection, oxidation stability, corrosion control, filterability, hydrolytic stability, and cleanliness under defined test conditions. As a result, both zinc-free and ashless formulations can obtain the same OEM approvals if they demonstrate equivalent performance in these areas.

How to know if you're looking at a zinc-free or ashless fluid?

Although OEMs do not distinguish between zinc-free and ashless, they do pay attention to the sulphated ash content of the finished oil. Sulphated ash is a measure of the inorganic residue remaining after the oil has been carbonised, and the residue subsequently treated with sulfuric acid and heated to constant weight1.

Ashless hydraulic fluids, by definition, contain no metallic additives and therefore exhibit extremely low sulphated ash levels. Zinc-free hydraulic fluids eliminate zinc-containing anti-wear chemistry but may still contain small amounts of metal-based detergents, resulting in a low, but measurable, sulphated ash

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content. In practice, however, sulphated ash content in zinc-free formulations is typically almost negligible, and often below 0.01%.

So, what does this mean for end users?

Because OEM specifications focus on performance rather than additive chemistry, the choice between zinc-free or ashless formulations depends more on the end users' application requirements. Zinc-free fluids are increasingly preferred where a level of detergency provides additional value through improved deposit control, neutralisation of acidic by-products, and support long-term equipment reliability.

Ashless fluids are appropriate for applications where even trace levels of inorganic ash are unacceptable. These include electrohydraulic servo systems with extremely tight component clearances, aerospace and aviation hydraulics, certain food and pharmaceutical manufacturing equipment, and environmentally sensitive applications where low-toxicity or readily biodegradable formulations are specified. In these systems, eliminating metallic detergent and anti-wear additives helps minimise deposit formation, reduce the risk of valve sticking, and maintain long-term system cleanliness.

The value of a hydraulic fluid is ultimately measured by its ability to protect equipment, maintain efficiency, and support reliable operation throughout the service interval. For many industrial systems, modern zinc-free formulations provide an effective balance of performance, durability, and sustainability.

Hydraulic fluid technology continues to evolve alongside increasingly demanding equipment designs, and zinc-free fluids demonstrate that high-performance anti-wear protection can be achieved without relying on heavy metals. The presence of small amounts of calcium in zinc-free systems is not a compromise but a deliberate design choice that enhances cleanliness, oxidation control, and long-term system stability.

By understanding the chemistry behind these technologies, lubricant marketers and end users can move beyond simple product labels and make more informed decisions. Rather than focusing solely on whether a fluid is zinc-free or ashless, selecting the right formulation should be based on application requirements, desired performance and sustainability objectives. In many applications, particularly those combining high loads, elevated temperatures, and environmental sensitivity, zinc-free formulations with controlled detergency offer an effective pathway to achieving both sustainability goals and robust equipment protection.

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Key Takeaway

- Zinc-free and ashless hydraulic fluids are not the same thing. While both eliminate zinc-containing anti-wear chemistry, zinc-free formulations may still contain small amounts of metal-based detergents.
- OEM approvals are typically based on performance requirements such as wear protection, oxidation stability, corrosion control, filterability, hydrolytic stability, and cleanliness rather than additive chemistry.
- In zinc-free formulations, detergents provide benefits beyond deposit control, helping neutralize acidic oxidation by-products and support long-term system cleanliness and reliability.
- The choice between zinc-free and ashless technologies should depend on application requirements, operating conditions, and sustainability objectives.
- Ultimately, hydraulic fluid performance remains the most important criterion for fluid selection.

Reference

[1] – ASTM D874 definition

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