



Balancing Performance and Protection in Modern Diesel Engine Lubrication

Introduction: Rising Demands on Diesel Engine Lubricants

Today's modern diesel engines are more advanced and more demanding than any generation before. Across on-highway, construction, infrastructure, mining, and other heavy-duty industries, equipment manufacturers are designing engines that operate at higher pressures, higher temperature, and stricter emissions standards than ever before.

While these advancements improve fuel efficiency and reduce environmental impact, they also place significantly greater demands on the lubricants used to protect engine components.

Heavy-duty fleets now expect engine oils to deliver performance across multiple areas, simultaneously offering:

- ✓ Protection against wear and under high-load conditions
- ✓ Stability at elevated operating temperatures
- ✓ Compatibility with emissions control systems
- ✓ Support for extended oil drain intervals
- ✓ Improved fuel efficiency and economy

Meeting all of these requirements at once is increasingly complex.

For lubricant formulators, the challenge is no longer simply preventing engine wear. It's achieving the right balance of protection, efficiency, economy, and emissions system compatibility.

Industry Challenges in Modern Diesel Modern Lubrication

Modern heavy-duty engines now operate under conditions that are significantly more demanding than ever. Higher combustion pressures, elevated operating temperatures, and tighter emissions requirements all contribute to a more complex operating environment for engine oils. At the same time, new emissions-control technologies, such as Diesel Particulate Filters (DPFs) and selective catalytic reduction systems, require lubricants that not only protect engine components, but also support the long-term durability of aftertreatment systems.

As engine and lubricant technologies continue to advance, the challenges facing lubricant formulators are expected to increase as well. Achieving the right balance between engine protection, emissions-system compatibility, and operational efficiency has become an increasingly complex goal.

The Shift Toward Lower Viscosity Oils

Another key industry trend influencing the lubrication development industry is the push toward lower viscosity oils to support improved fuel economy. Lower viscosity lubricants, such as SAE 10W-30, reduce internal engine friction, allowing engines to operate more efficiently and consume less fuel. This trend is reflected in the development of the upcoming API PC-12 heavy-duty oil category, which will introduce new performance standards designed to support next generation heavy-duty engines and improved fuel efficiency targets.

However, lower viscosity also creates new technical challenges. As lubricants become thinner, maintaining sufficient film strength and wear protection becomes more difficult, particularly in high-load heavy-duty applications. As a result, engineers must design additive systems capable of delivering strong protection even under increasingly demanding operating conditions.

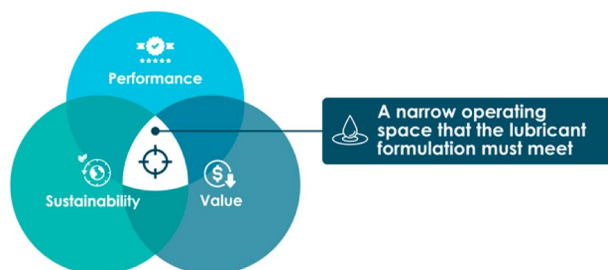
Increasing Complexity in Lubricant Formulation

In addition to stringent emissions regulations and efficiency goals, lubricant formulations must also adapt to changing engine designs, new materials used in engine components and the growing diversity of fuel types. These evolving factors further complicate lubricant development and require greater levels of innovation in additive chemistry.

As a result, modern engine oils must deliver balanced performance across multiple categories:

- ✓ Fuel efficiency
- ✓ Wear protection
- ✓ Oxidation stability
- ✓ Emissions system compatibility

Lubricants as Enablers



Source: [Infineum's Formulating the Future](#)

Balancing these requirements has become one of the biggest challenges in modern lubricant formulation today. Modern engine oils must deliver strong performance across multiple protection categories without compromising engine durability or emissions system compatibility. This balance requires carefully engineered formulations that optimize multiple performance factors simultaneously.

Balancing engine protection, emissions compliance, and efficiency is more challenging than ever.



CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 superior TBN retention and its balanced additive package help keep engines protected under demanding conditions.

Engineering the Right Balance in Additive Formulation

Many engine oils are formulated to excel in one specific area. Some prioritize low ash content to extend DPF life, while others focus on maximizing wear protection or engine cleanliness.

However, these specialized formulations often come with tradeoffs. For example, extremely low-ash oils may protect emissions systems but sacrifice wear protection or engine cleanliness.

CITGO® CITGARD® 700 Synthetic Blend Engine Oil SAE 10W-30 was designed to avoid compromise.

This premium API CK-4 heavy-duty engine oil uses a balanced detergent package that combines calcium and magnesium additives, rather than relying heavily on a single detergent chemistry.

This unique, balanced formula provides several advantages:

- ✓ Strong Total Base Number (TBN) retention for acid neutralization
- ✓ Improved ash characteristics that support DPF life
- ✓ Effective engine cleanliness and deposit control
- ✓ Consistent wear protection across operating conditions

By balancing these additive technologies, CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 achieves high performance across multiple protection areas rather than optimizing a single category at the expense of others.

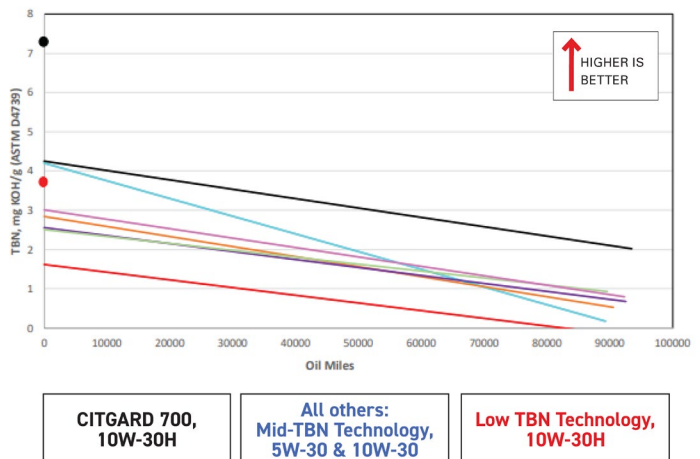
Technical Performance Advantages

The balanced chemistry behind CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 translates into measurable performance cross several key engine protection areas.

TBN Retention and Acid Neutralization

TBN represents an oil's ability to neutralize acids generated during combustion. Strong TBN retention helps prevent corrosion and extend engine life.

CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 has among the highest TBN and TBN retention performance in the industry. TBN retention of CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 protects against acid accumulation, leading to reliable engine durability.





CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 delivers outstanding stability for cleaner operation and extreme conditions.

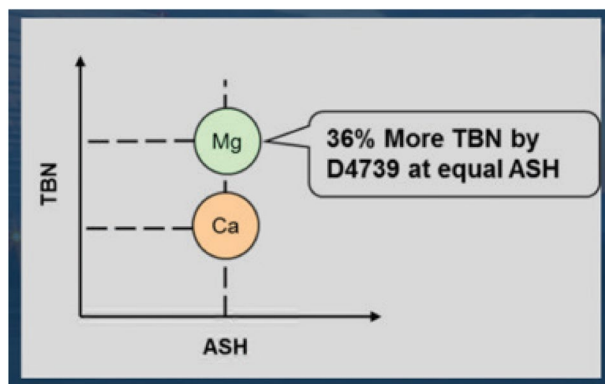
Technology	85K TBN
CITGARD 700	2.3
Low TBN Technology	0
Mid TBN Technology (average)	1.0

In a 500,000-mile, three-year field trial involving 42 trucks equipped with Cummins X15 engines, CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 demonstrated superior TBN retention compared to competing oils.

At approximately 85,000 miles into the oil drain interval, competing oils exhibited TBN levels roughly half that of CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30. One low-TBN competitor reached zero remaining TBN at this interval.

CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 maintains this high TBN through long oil drain intervals due to its balanced detergent additive package (roughly equal amounts of calcium and magnesium detergents) versus many competitors that have calcium-only detergent packages.

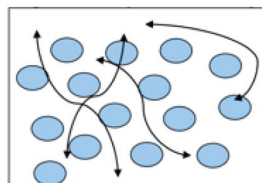
Magnesium ash is more porous and less dense than calcium ash, producing 36% more TBN than calcium at equal ash (ASTM D4739):



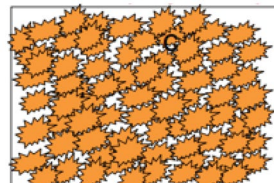
The benefits of utilizing magnesium ash include:

- ✓ Reduced exhaust flow resistance
- ✓ Reduced back pressure (50%)
- ✓ Less workload on engine
- ✓ Improved fuel efficiency

High Magnesium Ash
High Porosity-Low Density

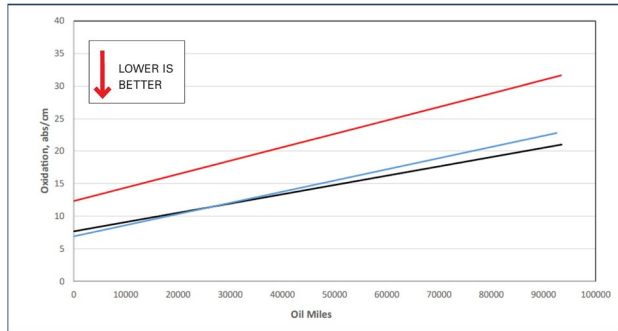


High Calcium Ash
Low Porosity-High Density



Oxidation Stability and Oil Longevity

Oxidation occurs when oil reacts with oxygen at high temperatures. Over time, oxidation can lead to oil thickening, sludge formation, and varnish deposits that reduce engine efficiency and increase wear.



**CITGARD 700,
10W-30H**

**Mid-TBN Technology,
5W-30 & 10W-30**

**Low TBN Technology,
10W-30H**

Basic lubricant applications (image from CITGARD Off Road and Mystik® Heavy Duty Grease webinar)

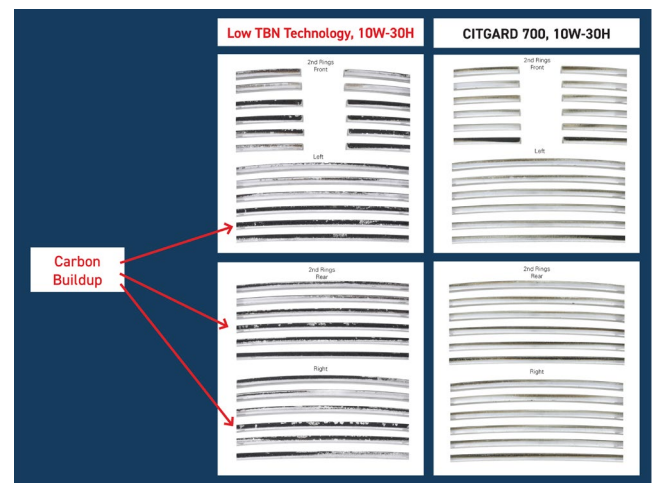
CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 demonstrates excellent oxidation control, helping maintain viscosity and prevent deposit formation.

Testing based on the Volvo T-13 Oxidation Stability Test shows that oil provides up to 100% greater oxidation protection compared to conventional CJ-4 oils. Strong oxidation stability helps maintain:

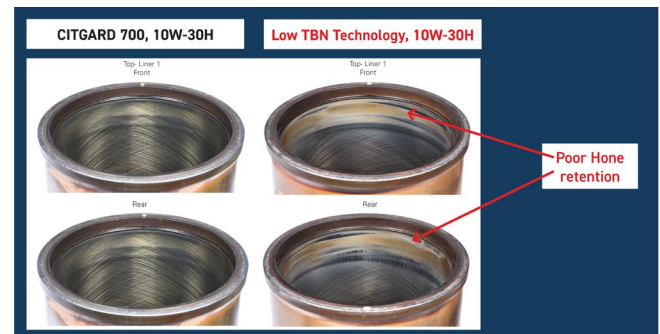
- ✓ Engine cleanliness
- ✓ Oil viscosity
- ✓ Fuel efficiency
- ✓ Long-term engine durability

Wear Protection and Engine Durability

High-load conditions, extreme temperatures, and modern fuel systems place significant stress on engine components. Field trials show that engines using CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 retained visible cylinder honing marks, indicating minimal wear, while competing oils show greater component wear. Piston rings also had significantly lower carbon buildup, demonstrating effective deposit control and engine cleanliness.



CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 detergent package helps maintain engine cleanliness compared to carbon buildup on the low TBN Technology 10W-30 rings.



Wear Protection Evidence - Cylinder honing marks are still present in the CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 cylinders showcasing the oil's superior protection. Significant wear is present in the cylinders using the low TBN technology 10W-30.

Supporting DPF Life Through Balanced Chemistry

DPF captures particulate matter from engine exhaust, including soot and ash. While soot from combustion can be burned off through a process called regeneration (either passive, active, or forced), ash from metallic lubricant additives is noncombustible and gradually accumulates in the filter. Over time, this buildup increases exhaust backpressure, which can reduce engine performance and fuel efficiency, eventually requiring the DPF to be cleaned or serviced. Factors such as engine condition, oil quality and consumption, fuel quality, engine load, and driving conditions can influence regeneration frequency and ash accumulation.

Because lubricant additives contribute to ash formation, oil chemistry plays a key role in DPF performance. The ash produced during combustion can accumulate inside the filter and increase exhaust backpressure.

The balanced detergent package of CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 helps manage ash characteristics to support DPF performance. Magnesium ash particles are more porous and less dense than calcium ash, improving exhaust gas flow and reducing restriction. Overall, this decreases workload on the engine and improves fuel efficiency.

In the 500,000-mile field trial, trucks using CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 did not need to change the DPF and there were no concerns regarding backpressure build-up, which can hurt fuel economy.

Fuel Efficiency and Operating Costs

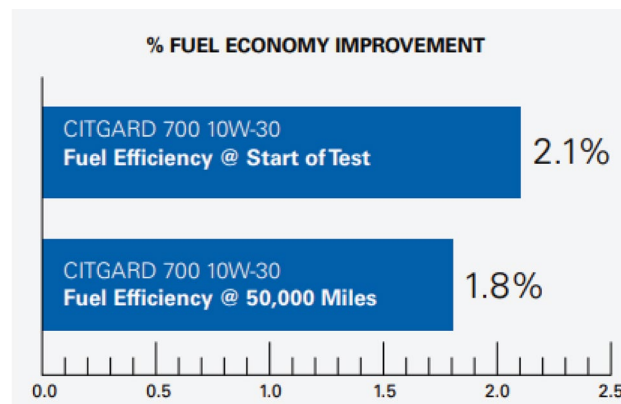
Fuel costs represent one of the largest operating expenses for most fleets. Lubricant viscosity and formulation can play a significant role in improving overall fuel efficiency.

The SAE 10W-30 viscosity grade used by CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil helps reduce internal engine friction compared to traditional SAE 15W-40 oils.

Testing shows that 10W-30 oils can provide up to 3% economy improvement over their conventional 15W-40 counterparts.

Field data shows CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 delivers:

- ✓ ~2.1% fuel efficiency improvement compared to 15W-40
- ✓ Sustained 1.8% fuel efficiency improvement after 50,000 miles over time



For large fleets, even small improvements in fuel efficiency can translate into substantial cost savings.

Construction Fleet Application

Construction fleets face a different challenge – maximizing equipment uptime. Unlike long-haul trucking operations, many construction companies generate revenue only when their equipment is actively working. Any unexpected downtime directly impacts productivity and profitability.

Fleets operating construction equipment have reported benefits from the balanced protection offered by CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30, including reliable engine protection and simplified lubrication programs across multiple equipment types.



Real-World Validation: Brundage Bone Concrete Pumping Case Study

[Brundage Bone](#) operates the largest concrete pumping fleet in the United States, with over 480 vehicles across 80 brand locations.

Fuel costs represent one of the company's largest operating expenses.

After evaluating their lubrication program with CITGO technical experts, Brundage Bone transitioned from a traditional 15W-40 oil to CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30.

Following six months of monitored fleet performance using independent telematics data, the company reported fuel cost reductions of up to 2.5% annually.

For a fleet of this size, even small improvements in fuel economy translate into meaningful operation savings.

The Importance of Lubricant Balance

The experiences of fleets such as Brundage Bone highlight a key principle of modern diesel lubrication: performance depends on balance. Engine oils must deliver protection across multiple dimensions simultaneously.

Balanced formulations provide:

- ✓ Effective wear protection for critical engine components
- ✓ Resistance to oxidation and viscosity breakdown
- ✓ Compatibility with modern emissions systems
- ✓ Support for efficient engine operation

Conclusion

As diesel engine technology continues to evolve, the demands placed on engine oils will only increase. Fleets must select lubricants that deliver consistent protection across multiple performance areas without introducing tradeoffs.

[CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30](#) was developed with this challenge in mind. Its balanced formulation combines advanced additive technology with carefully engineered detergent chemistry to deliver strong performance across the most critical areas of engine protection.

Field trials and fleet experience prove that this balanced approach can deliver measurable benefits, including improved fuel efficiency, strong wear protection, reliable oxidation stability, and long DPF service life, without sacrifice.

For fleets seeking to improve reliability, reduce operating costs, and protect modern diesel engines and emissions systems, CITGO CITGARD 700 Synthetic Blend Heavy Duty Engine Oil SAE 10W-30 offers a proven solution that balances engine protection with operational efficiency.

The CITGO family of brands:



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