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Understanding Diesel Engine

What is a Diesel Engine?

Diesel engines are a class of internal combustion engines in which the fuel burned internally, and the combustion products used as the working fluid. Unlike the spark-ignited (SI) engines found in the majority of today's automobiles in which an electric spark ignited the premixed fuel-air mixture. Diesel engines characterized by a spontaneously initiated combustion process where the ignition is brought about by very high temperature compressed air. A small amount of diesel fuel injected at the end of the compression stroke into the cylinder where the fuel auto-ignites.

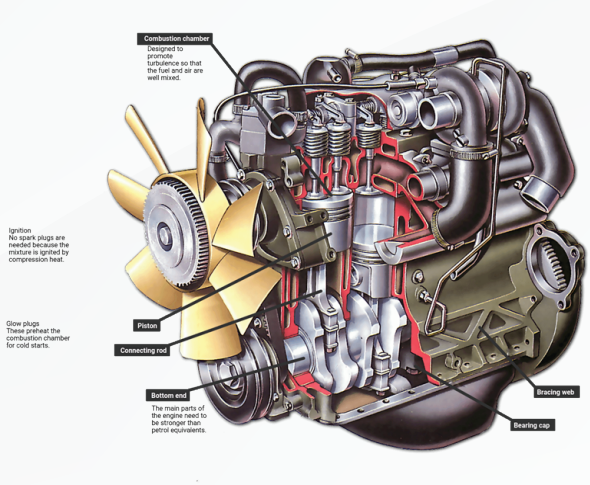


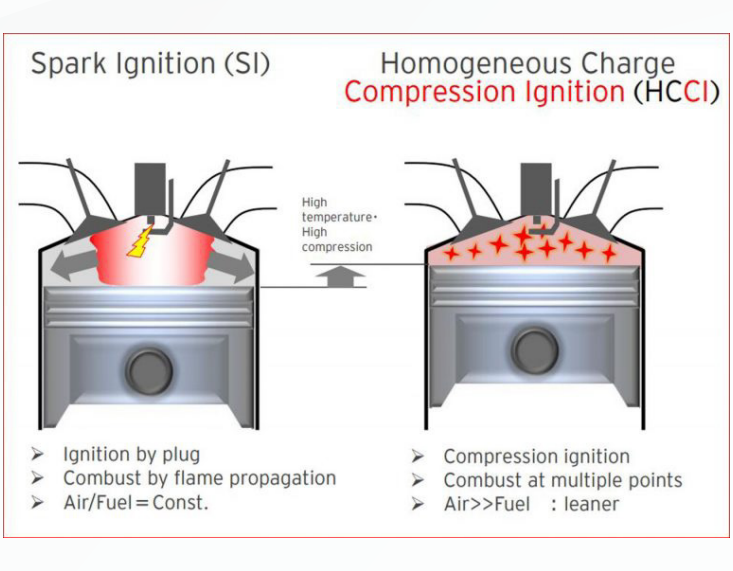
Image the compression-ignition engine

(Source : https://www.howacarworks.com/basics/how-a-diesel-engine-works)

Difference between Diesel and Petrol engine

Diesel engines and petrol engines are quite similar. They are both internal combustion engines designed to convert the chemical energy available in fuel into mechanical energy. This mechanical energy moves pistons up and down inside cylinders. The pistons connected to a crankshaft, and the up-and-down motion of the pistons, known as linear motion, creates the rotary motion needed to turn the wheels of a car forward.

Both diesel engines and petrol engines convert fuel into energy through a series of small explosions or combustions.



Spark ignition vs. HCCI engine (source: Mazda)

Diesel	Comparison	Petrol
Diesel engine has no spark plug, that intakes air and compresses it, and that it then injects the fuel directly into the combustion chamber (direct injection).		In a petrol engine, fuel is mixed with air, compressed by pistons and ignited by sparks from spark plugs.

Is it ok to use Diesel Engine oil in the Petrol Engine?

Diesel oil typically contains more robust detergency additives than petrol oils. But, it is safe to use diesel oil in your petrol engine, provided the diesel oil meets the appropriate specifications and viscosity requirements of your engine.

Engine calls for motor oil that meets the API SN specification, you can safely use a diesel oil of the correct viscosity that meets the API SN spec. For the typical petrol application, however, diesel oil isn't required, and the more appropriate choice is a quality petrol motor oil for both performance and value.

Evolution to Revolution

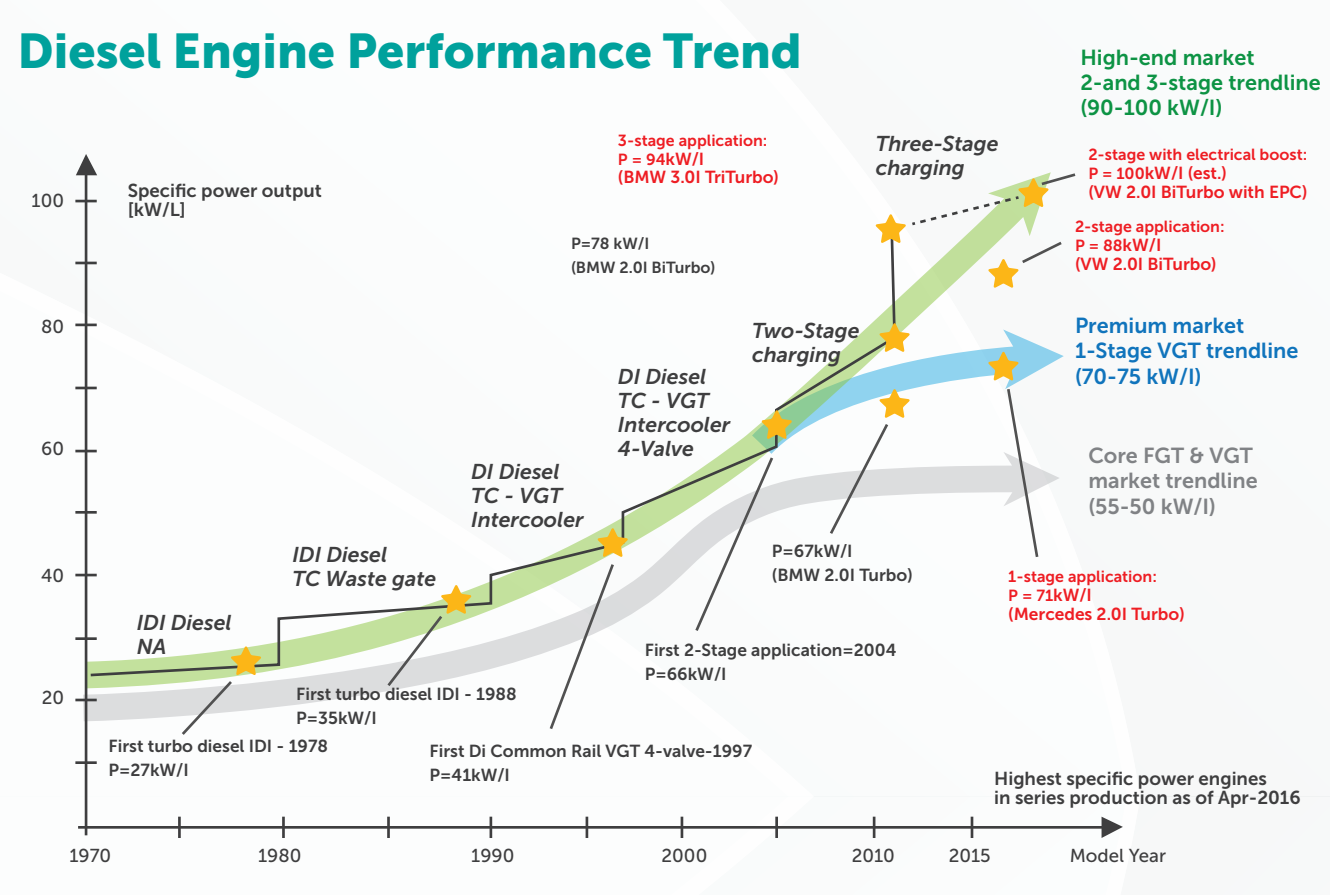
Over the last 40 years, heavy-duty diesel engine designs have evolved substantially. This evolution has driven by emission legislation and customers' requirements for efficiency and reliability. There has been significant progress. For example, high-pressure, common-rail injection systems are now widely used to improve combustion efficiency.

Advances in turbocharger technology have increased specific power output and exhaust gas recirculation and aftertreatment devices.

Despite this progress, such as diesel particulate filters and selective catalytic reduction, have curbed harmful emissions of oxides of nitrogen and particulate matter (i.e., soot) to follow the recent regulations.

The user's desire to reduce the total cost of ownership, are making fuel economy the most critical driver for engine manufacturers. Advanced technologies and materials and new operating conditions such as higher internal temperatures continue to improve engine efficiency.

Diesel Engine Performance Trend



Diesel engine specific power evolution

(Source : https://www.researchgate.net/publication/312033403)

Along with the evolution of heavy-duty engine technology, the technology of exhaust gas aftertreatment systems has improved substantially as well. To meet Euro VI emission standards, OEMs use EGR (exhaust gas recirculation), SCR (selective catalytic reduction) and DPF (diesel particulate filter) technology. Some OEMs minimize the EGR dosage or entirely refrain from EGR.

The evolution of engine technology and improvement of engine characteristics have an impact on load (e.g., thermal, soot due to exhaust gas recirculation) on engine oil. Moreover, the use of exhaust gas aftertreatment devices imposes requirements for the chemical composition of engine oils

API Oil Service Categories

The API Engine Oil Licensing and Certification System provides a simple designation of letters and numbers that allows engine manufacturers and oil marketers to give the users the information they need to ensure that the proper oil selected for an engine.

Each letter/number designation identifies a service category (e.g., CI-4), which linked to a series of tests that the oil must pass before it can carry that designation.

The API "S" series describes oil standards primarily for petrol engines while the API "C" series describes oil standards for diesel engine service. A description of the API service symbol and category mark can found in the Engine Oil Guide published by the API.

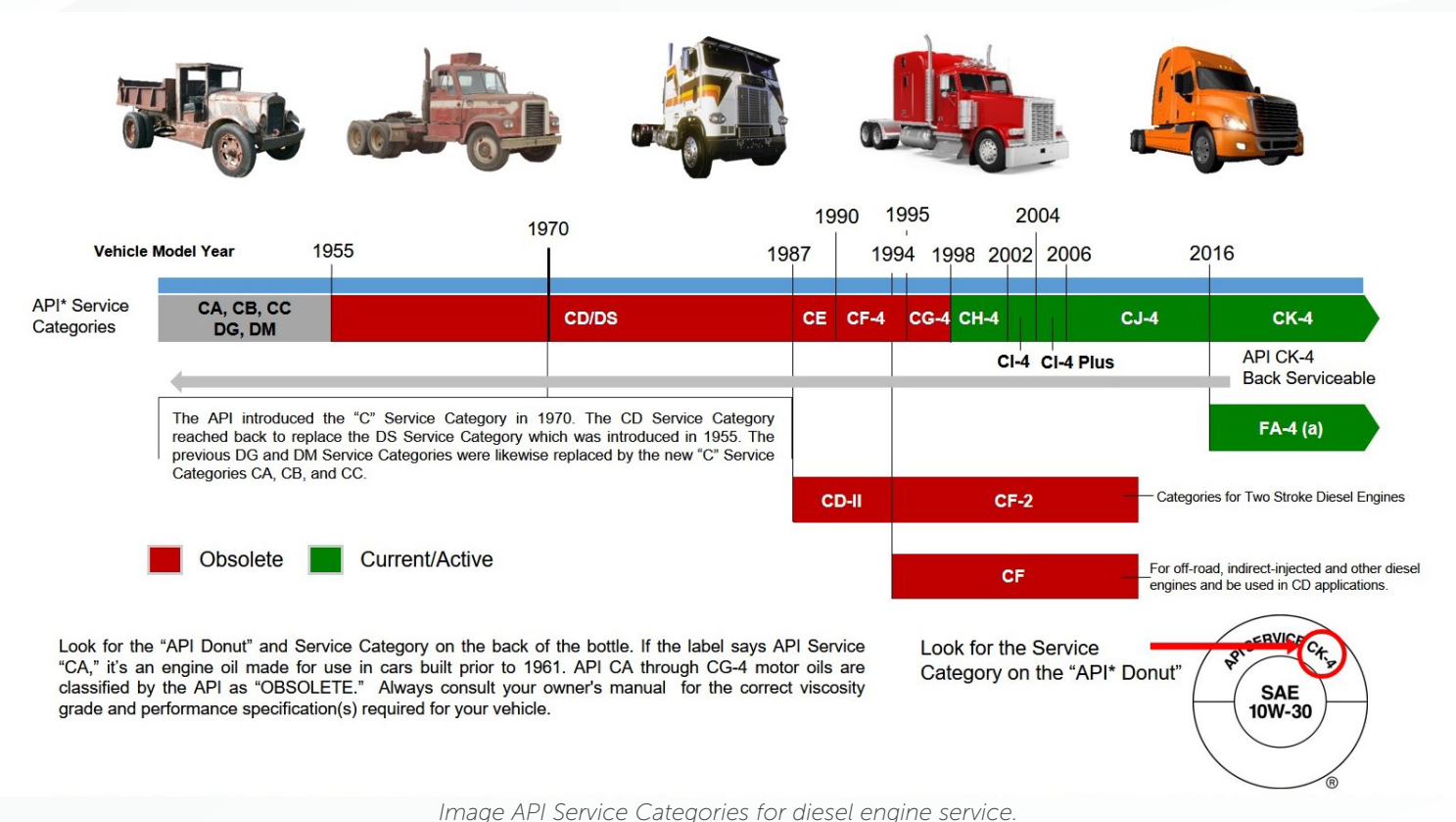
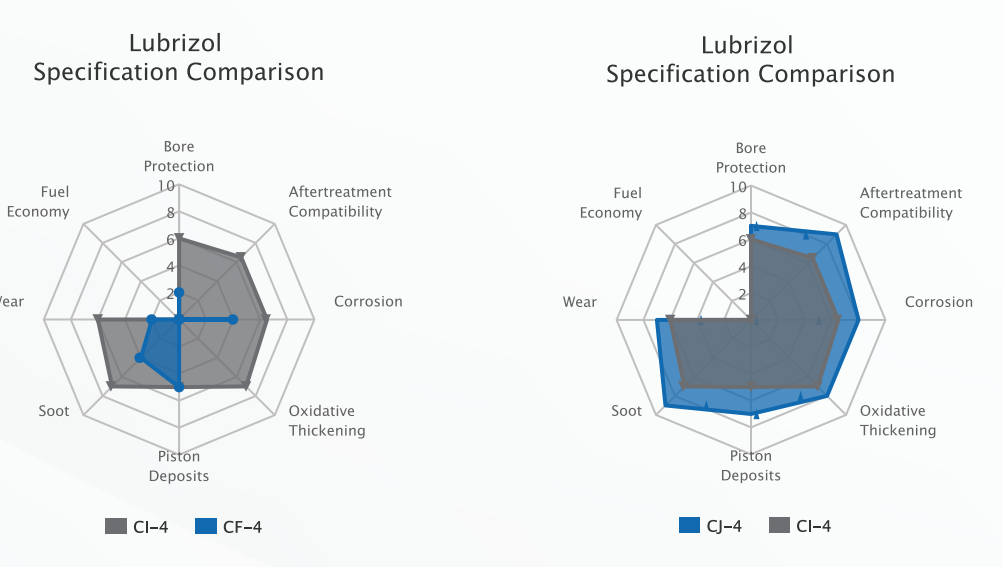


Image API Service Categories for diesel engine service.

(Source : The Petroleum Quality Institute of America -PQIA)

What do we understand about the API spider web specification?



Specification comparison between API CF-4, API CI-4 and API CJ-4 performance

(Source : https://online.lubrizol.com/relperftool/hd.html)

API specification, specify engine oil performance based on a few main tests as following;-

- Bore protection – polishing can cause loss of combustion and increase fuel used
- After treatment compatibility – part of the exhaust used to reduce the emission
- Corrosion – rust resulted by the oxidation metal
- Oxidative thickening – high temperature causes the viscosity increase to thicken the oil
- Piston deposits – a form of deposits built up by reactive species in the combustion chamber
- Soot – a by-product of the unburn fuel formed a carbonized small particles
- Wear – damage causes by two body in contact
- Fuel economy – improve fuel consumption

The performance each of the factors tested, evaluate, and assess to meet specific standard value set up by the API organization. It presented in the simple spider web chart. In the spider web, it tells the comparison between two API specification for each of the test values required for the engine oil performance according to the specifications.

In the spider web chart above, Lubrizol specification comparison between API CI-4 and API CJ-4, we can see the different levels value of performance for each test. The different API engine oils specification indicates different API grades required different protection performance to meet with the various engine design and technology.

For example, API CI-4 developed to fulfill the EURO III engine, which generally equipped with the turbocharger, intercooler, and exhaust gas recirculation system. Which means, the new technology engine, it works at very high temperature and a lot of soot loading presented in the combustion chamber because EGR works by recirculating a portion of an engine's exhaust gas back to the engine cylinders. That is very important for the new engine oil API CI-4, to combat piston deposits, control oxidative thickening, and excellent soot control as compared to the API-CF performance.

API CI-4 also developed to meet the EURO IV engine model requirement. In the new EURO IV engine, apart from the general new component equipped in the system, SCR or selective catalytic reduction. In this emission control system, the amount of particular performance additive is limited; hence, new engine oil performance required to enhance the operation and performance, which is API CJ-4.

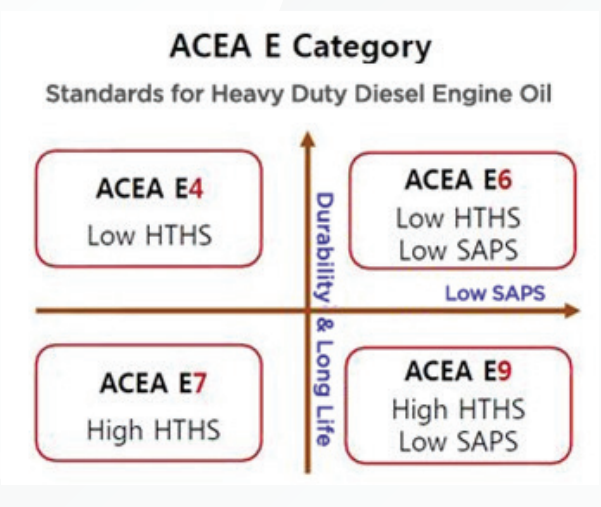
In the new engine technology such as EURO V and EURO VI, engine design is compact, light, higher performance, working at high temperature, and less pollution. New emissions system installed such as DPF, apart from SCR, EGR turbocharger at the engine, and for the requirement, API CJ-4 introduced to fulfill protection to the engine.

Category	Year of Introduction	Engine Service Description	Backward Compatibility
CF	1994	Intended for off-road engines that use fuel containing more than 0.5% sulfur. Provides control of : • Piston deposits • Piston, ring and liner scuffing • Wear and corrosion of copper-containing bearings	CD
CF-4	1991	Intended for high speed, 4-stroke, on-highway heavy-duty diesel engines meeting 1991 emission standards. Provides control of : • Piston deposits • Piston, ring and liner scuffing • Corrosion and wear of copper-containing bearings • Oil consumption • Ring and liner wear • Oil thickening due to soot	CD and CE
CG-4	1995	Intended for high speed, 4-stroke diesel used in on- and off-highway applications and using fuels with less than 0.5% sulfur. Especially for engines meeting 1994 emission standards. In addition to providing control of the parameters listed for CF-4 oils, the classification provides additional control of : • Oil filter plugging due to soot • Oil thickening due to oxidation • Valve train wear • Foaming	CD, CE, and CF-4
CH-4	1998	Intended for high-speed 4-stroke diesel meeting 1998 US EPA emission standards and using fuels with less than 0.5% sulfur. In addition to providing control of the parameters listed for CG-4 oils, the classification provides additional control of : • Viscosity loss due to shear • Sludge • Oil volatility	CF-4 and CG-4
CI-4	2002	Intended for high-speed 4-stroke diesel engines meeting 2004 US EPA on-highway emission standards implemented in 2002. Formulated to sustain engine durability where EGR used. Intended for use with fuels having less than 0.5% sulfur. In addition to providing control of the parameters listed for CH-4 oils, the classification provides additional control of : • Low-temperature pumpability • Elastomer compatibility • High-temperature/high-shear viscosity	CF-4, CG-4, and CH-4
CI-4 Plus	2004	Meets all requirements of CI-4 but includes increased resistance to oil thickening from soot and increased shear stability.	CF-4, CG-4, and CH-4
CJ-4	2006	Intended for high-speed 4-stroke diesel engines meeting 2007 US EPA on-highway emission standards. In addition to providing control of the parameters listed for CI-4 oils, the classification provides additional control of : • Sulfated ash, phosphorous and sulfur content	CI-4 and CI-4 Plus
CK-4	2017	Intended for high-speed 4-stroke diesel engines meeting 2007 US EPA on-highway emission standards. In addition to providing control of the parameters listed for CJ-4 oils, the classification provides additional control of : • Engine oil aeration • Engine oil oxidation • Viscosity loss due to shear	CJ-4
FA-4	2017	Intended for some high-speed 4-stroke diesel engines meeting 2017 US EPA on-highway emission standards. This classification provides the same benefits as CK-4 oils. Still, it also meant to enable fuel economy benefits for heavy-duty engines by introducing oils with lower high temperatures/high shear viscosity than CK-4 oils.	None

Table: API "C" series service categories and the general performance requirements that the oil must meet. The information on the minimum backward compatibility of specific categories. While newer service category oils generally provide backward compatibility to older service categories, they may not be compatible with all older categories

ACEA Heavy-duty Engine Oil Sequences

The ACEA European Oil Sequences define the minimum quality level of service fills oils that the automotive industry members of the European Union demand for use in their vehicles. Currently, the applicable ACEA claims for heavy-duty diesel engine lubricants are E4, E6, E7, and E9. The table below provides a brief overview of the applications of these lubricants.



ACEA standard for heavy-duty engine

**Note: SAPS - sulfated ash, phosphorus and sulfur.*
HTHS - high-temperature high shear

(Source : http://www.s-oil7.com/eng/knowledge/expert/view.jsp?seq=78)

The Silent Killers : Engine Deposits

Engine deposits will cause abrasive wear, starve engine parts of lubricants, and promote oxidation, wearing down critical engine parts and lead to eventual total engine breakdown. You will not see and feel the impact until the engine fails, often too late to salvage it for further use.

The Silent Killers : Engine Deposits

(Source : http://oilsludge.com/)

PETRONAS Urania with ViscGuard™

Why is PETRONAS Urania the better lubricant for my diesel-based commercial vehicle?

1 **PETRONAS Urania with ViscGuard™**
Uniquely formulated to effectively guard against engine deposits build-up, preventing abrasive wear and oxidation.

2 **PETRONAS Urania with ViscGuard™**
Formulated with a robust oil film, which disperses engine deposits to avoid these by-products to agglomerate on engine critical parts.

3 **PETRONAS Urania with ViscGuard™**
Guard against deposit build-up and Maintain optimal oil viscosity. It helps prevent unplanned downtime and ensures that your business commitments are met in full, day after day.

Formulations used for PETRONAS Urania with ViscGuardTM based on proven performance in many industry-standard engine & bench tests.