Chevron

Base Number

Lubricating oils for modern diesel engines are not only designed to provide adequate lubrication under varying temperatures and operating conditions, they also keep the engine clean and provide protection against chemical corrosion from acidic combustion products. These important properties are "added" to the lubricating oil by means of alkaline additives often referred to as detergents and dispersants.

Base number (BN)

A lubricant's BN measures its potential to neutralize the acidic products formed during combustion. These products are caused by sulphur in the fuel oil.

The BN is often referred to as "alkalinity." More specifically, it is the quantity of acid — expressed in terms of the equivalent number of milligrams of the alkaline potassium hydroxide — that is required to neutralize all alkaline constituents in one gram of sample. A BN of 70 for a typical slow-speed engine cylinder oil means that a quantity of acid equivalent to 70 milligrams of potassium hydroxide is required to neutralize the alkaline additives present in one gram of this oil.

Marine fuel oils contain varying amounts of sulphur, which can range from 0.3 to 4.5% by weight. During fuel combustion, the sulphur is oxidized to SO_2 and SO_3. Part of these sulphur oxides combine with water during combustion and form sulphurous and sulphuric acids. These acids are extremely corrosive to engine components and need to be neutralized to prevent corrosive wear. Bases are needed to neutralize acids. This means that oil-soluble bases must be present in lubricating oils used in internal combustion engines.

Oil-soluble bases

The most commonly used basic detergents in these bases are organic soaps and salts of alkaline earth metals such as calcium, barium and magnesium. Calcium and magnesium sulfonates and calcium phenates are widely applied. The trick is to connect an alkaline metal compound such as calcium carbonate, which is not soluble in lubricating oil, to other molecules so that the new compound is oil soluble and can neutralize acids without creating harmful side effects. Oil-soluble bases, such as calcium sulfonate and calcium phenate, are also excellent deposit control additives.

The most critical areas for deposit formation in diesel engines are the piston crown and ring area. Excessive deposit formation on the piston crown may cause bore polishing, whereas deposits building up in the piston ring area may result in ring sticking. These deposits cause improper sealing of the combustion chamber and result in loss of compression, blowby, loss of oil control, increased wear and subsequent problems. The deposits formed on the piston are a mixture of soot and ash. Soot originates from the incomplete combustion of hydrocarbons, and ash contains those components that cannot be further oxidized. These combustion by-products are not oil soluble.

To protect against deposit formation, the substances must be prevented from forming or the particles formed must be kept very small and be dispersed in oil to be removed, for example, through the centrifugal filter or separator or when the oil is drained. The oil-soluble bases, such as calcium sulfonates and calcium phenates, prevent the particles from coagulating and keep them in suspension.

Selecting the correct BN for a diesel engine lubricant depends on various factors such as engine design, specific application in the engine, and sulphur content of the fuel. The type of fuel applied also plays a major role in this decision.

Slow-speed engine cylinder lubricants

Slow-speed engine cylinder oils, used for once-through lubrication of cylinders and liners, must have a high BN to manage the acids formed during combustion of the heavy fuel oils burned in these engines. The engines sometimes have extremely large bores and long strokes and the surface to protect is huge. Therefore, sufficient alkalinity must be available close to the oil quill as well as far below.

The amount of alkalinity introduced in the combustion chamber is directly linked with the oil feed rate and the BN of the applied cylinder oil. The amount of sulphuric acid generated from the combustion process is directly linked to the sulphur content in the fuel and the engine load. It is important to maintain a correct balance between them. Excess alkalinity may potentially cause deposit formation, whereas a shortage in alkalinity leads to excessive corrosion. In a correctly balanced system, corrosion is controlled rather than prevented, preserving a proper liner surface structure, which allows a strong oil film to build up.

Engines operating continuously with heavy fuel oil with high sulphur content (> 2%wt) typically use 70 BN products. However, engines operating continuously with low sulphur content heavy fuel oil (< 1%wt) typically use a 40 BN cylinder oil. These are only guidelines; for specific cases, please refer to the engine manufacturer's documents.

Slow-speed engine system oils

Slow-speed engine system oils, used in engines with oil cooled pistons, must possess some degree of detergency/dispersancy to ensure clean crankcase and piston interiors. A moderate alkalinity level in the oil also neutralizes the acidic combustion products that may leak into the crankcase through the stuffing box seals. The average BN levels for fresh system oils range from five to ten.

There are no minimum limits set for the BN of used slow-speed engine system oils. It is normal to see the BN of these oils increase over time from the ingress of used cylinder oil. However, a sudden increase in BN may indicate severe leakage through the stuffing box seals.

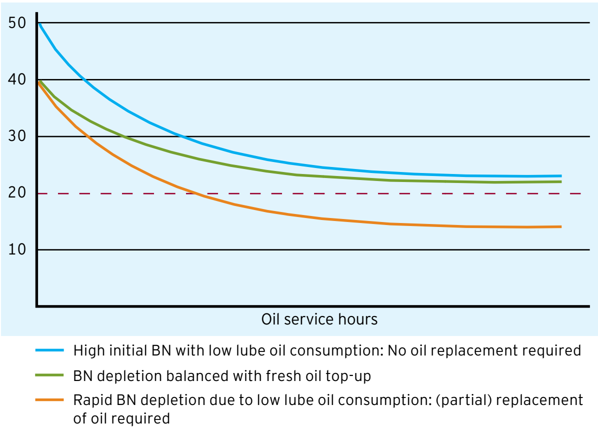
Medium-speed engine lubricants

Medium-speed engine oils, used for the lubrication of cylinders, liners, and bearings, are available with various BN levels. The BN requirements are specified by the engine manufacturer.

Table 1 presents a summary of typical BN requirements for medium-speed engines shown by function of the applied type of fuel and its sulphur content. The information in this table should only be used as a guideline. For specific cases, please refer to the engine manufacturer's documents.

Oil consumption is an important factor to consider when selecting the appropriate BN level of a lubricant. Lube oil in low-consuming engines depletes faster because less BN is topped-up during operation. Examples of typical medium-speed engine BN depletion curves are shown in Figure 1.

Figure 1: BN depletion of medium-speed engines



Other features in engine design also play roles in the selection of the appropriate BN level. An engine equipped with bore polishing rings can use higher BN oil because the deposit buildup on the piston is mechanically limited.

Many engine manufacturers specify the minimum required BN level of the oil in service in relation to the fuel in use. Their limits should be considered when judging used oil analysis results. As guideline, the BN of used diesel engine oil should be greater than 50% of the fresh oil value. ■

Table 1: Base number requirement guidelines – medium-speed engine oils

Fuel type	Sulphur, mass %	Fresh Oil BN
Gas Oil	< 0.5	5 – 15
Marine Diesel Oil	0.5 – 1.8	10 – 20
Intermediate Fuel Oil	1.0 – 3.0	15 – 30
Heavy Fuel Oil	0.3 – 3.0	20 – 40
Heavy Fuel Oil	> 3.0	30 – 60