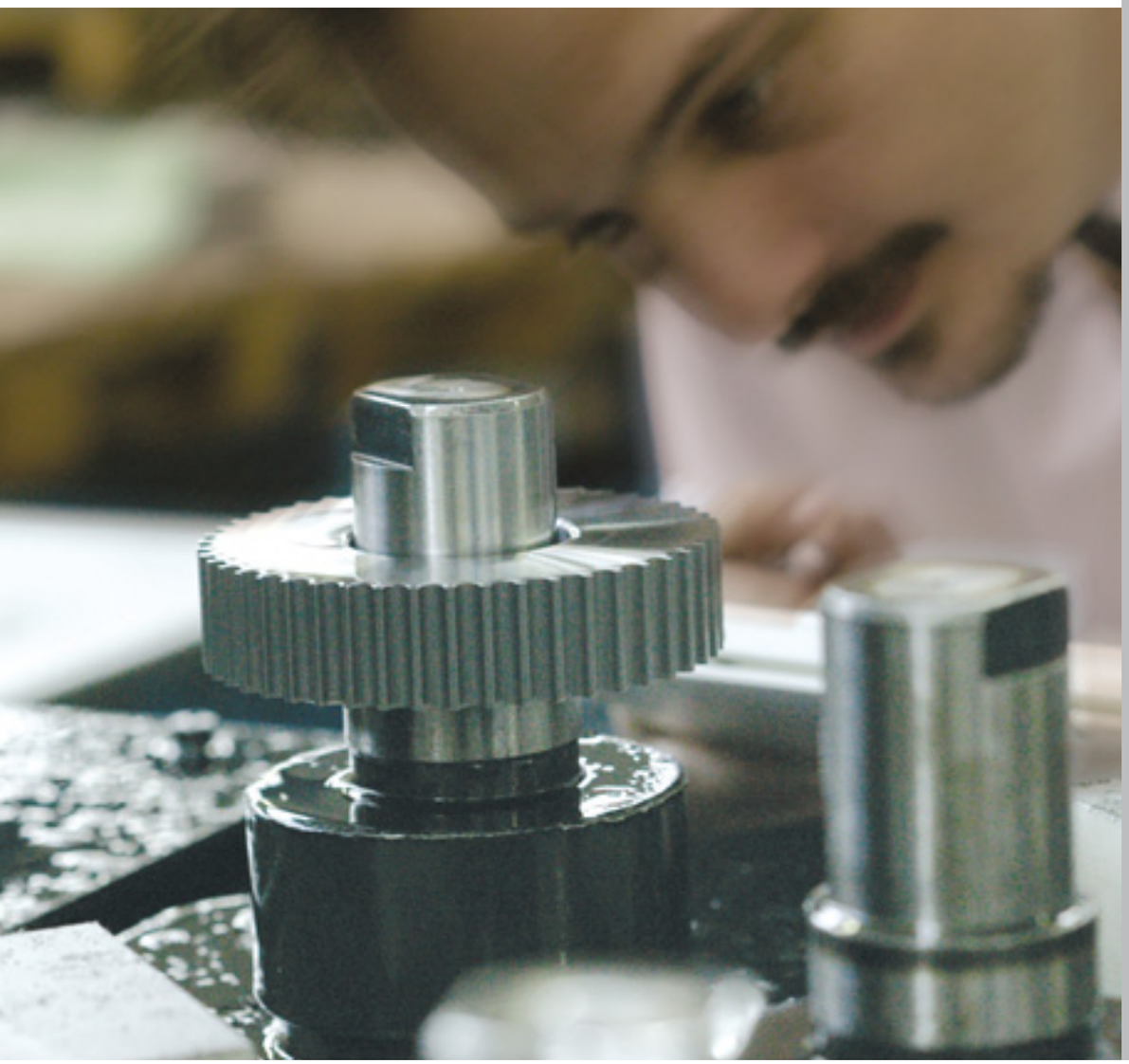
Higher performance

through longer life of gear units



Castrol™

High-performance gear oils that extend gear life and increase productivity

Castrol offers you a complete range of world-class gear oils and product support services designed to deliver:

> Longer gear life
> Optimum gear performance
> Extended maintenance intervals
> Increased productivity
> Decreased maintenance costs
> Lower overall oil consumption and waste

We can offer you these benefits because of the global process and applications expertise of our network of engineering and research professionals. Just as important, we deliver them through our knowledgeable local sales and support teams, who work with you to achieve proven performance in your manufacturing environment.

Our commitment, your advantage

Castrol lubricants have been formulated using the latest raw materials and tested in both laboratory and manufacturing conditions in close co-operation with leading gear and machinery manufacturers. Choose our high-performance gear lubricants and you gain the advantage of:

> Excellent lubricating film
> Dissipation of friction heat
> Reduction in friction and wear
> Avoidance of scuffing, grey staining and pitting
> Increased load carrying capacity
> Protection against corrosion
> Compatibility with paints and elastomers
> Good filterability
> Water separation

Evaluating oils with plastic deformation characteristics

Testing for scuffing load carrying capacity

The minimum FZG scuffing load requirements to be met by CLP gear oils according to DIN 51517, part 3, (the evaluation of wear protection properties) is stipulated as failure load stage 12. The FZG scuffing load carrying test method is DIN 51354.

The FZG scuffing load carrying test was developed by the Research Institute for Gear Wheels and Gear Construction (Forschungsstelle für Zahnräder und Getriebebau - FZG) to evaluate the scuffing properties of a gear oil.

The test is usually carried out in eight load stages up to load stage 12. The load in the scuffing load stage 12 corresponds to a Hertzian contact pressure of approximately 1850 N/mm^2. To assess enhanced performance the FZG load can also be increased to load stage 14.

The failure load stage reached in the FZG test is included in the gear design calculations of many gear manufacturers. In addition, the failure load stage obtained is taken into account by the gear calculation according to DIN 3990.

In the FZG scuffing load carrying test, the optical appearance of the tooth flanks is evaluated. Under this test, gear oils with Plastic Deformation (PD) characteristics pass load stage 12 without failure.

As a result, gear units lubricated with gear oils featuring PD characteristics are highly protected against wear and pitting even when subjected to overload. As trials in heavily loaded wind power stations have confirmed, the high scuffing load carrying capacity still prevails after long operating periods.

FZG load stage test A / 8.3 / 90

Load stage	Hertzian pressure (N/mm^2)	Performance range	Evaluation
6	927	HLP hydraulic oils DIN 51524	Medium surface pressure at average to highly loaded gears
7	1,080		
8	1,232		
9	1,386	CLP gear oils DIN 51517.3 AGMA 250.04	Peak values e.g. at shock loads
10	1,538		
11	1,691		
12	1,841	Gear Oils with PD characteristics	
13	2,001		
14	2,136		

Gear oils with PD characteristics surpass the requirements for CLP oils

Test gear of the FZG test rig

Gear oils with plastic deformation characteristics protect against wear and pitting... and may even smooth existing damage

FZG grey staining test (micro-pitting)

Grey staining is defined as the formation of small cracks on the tooth flanks that appear to the naked eye as grey spots on the gear teeth. This type of damage in modern gear construction can emerge after a short operating period.

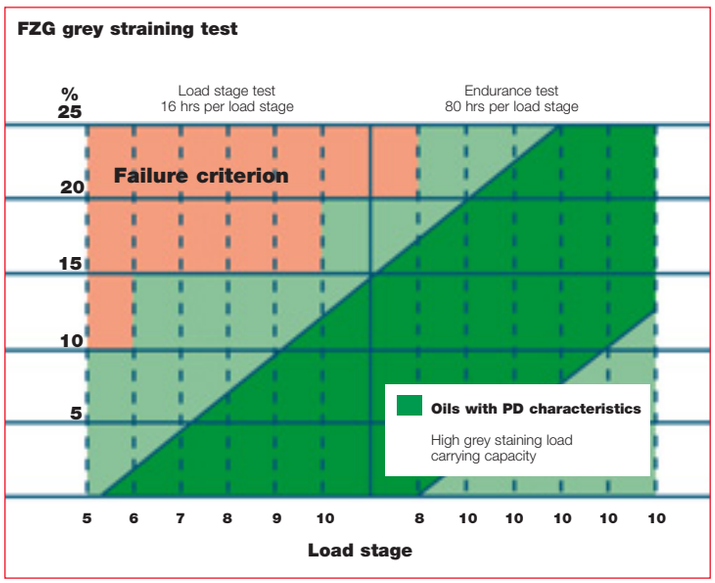
Unlike the FZG scuffing load carrying capacity, the evidence of a high grey staining load carrying capacity is not yet part of the internationally acknowledged gear oil standards DIN 51517 or AGMA 250.

Even so, many European gear manufacturers have included the evidence of grey staining load carrying capacity in their specifications. The grey staining load carrying capacity of an oil can be determined by way of a test run that is similar to the FZG scuffing load test. The results of this test are divided into three groups – low, medium and high grey staining load carrying capacity.

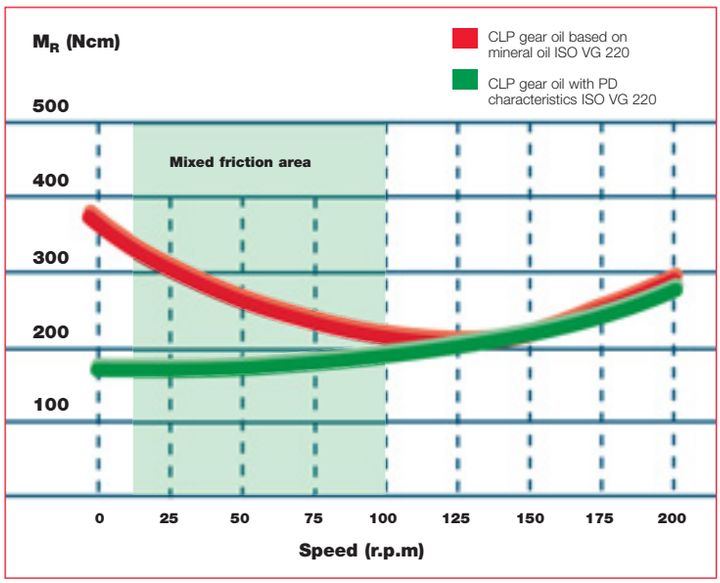
An evaluation measure for gear oils featuring a high grey staining load carrying capacity is the formation of grey stained areas that should not exceed 20% of the total surface, as well as a gear profile deviation that should not go beyond a limit of 20 µm.

All gear oils with Plastic Deformation (PD) characteristics have passed this test successfully with the rating of 'high grey staining load carrying capacity'. Therefore, the application of these gear oils effectively helps to reduce grey staining damage or will even smooth already existing damage.

Grey staining is fatigue damage that results from insufficient lubricating film or excessively high sliding speed



Test procedure for grey staining load carrying capacity



The PD additives immediately form an anti-friction protective layer in the contact area

Frictional corrosion (SRV test)

The SRV test according to DIN 51834 is a test procedure through which a reduction of friction can be quantified. Apart from the size of the wear scar, the coefficient of friction is also recorded during the test period. In this test, gear oils with PD characteristics achieve a value of 0.06 µ to 0.09 µ, while gear oils with conventional additives can reach a value that is about twice as high.

SKF rolling bearing test (LAD 100)

The test used in tapered roller bearings known as SKF test LAD 100 B is more practical than the SRV test.

At different loads, a curve of the starting frictional torque is recorded as a function of the speed. The effect of the PD additives is clearly proven by the reduction of frictional torque by **half** compared with conventional gear oil.

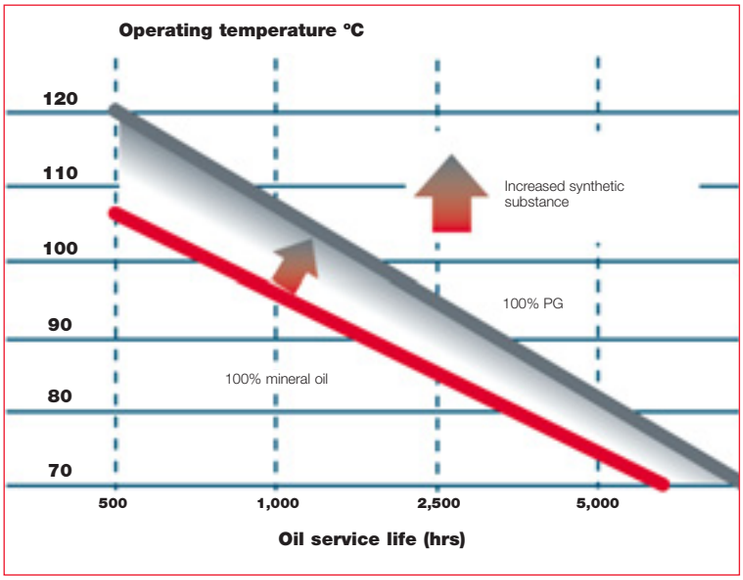
At higher rotational speeds – in this case approximately 120 r.p.m. – a hydrodynamic lubricating film is formed that completely separates the friction partners from each other. At this operating stage, friction behaviour is no longer influenced by the additives but only by the viscosity of the oil.

Choosing the right gear oil greatly influences the costs of the plant, its service life and customer satisfaction

Temperature behaviour

The temperature level of an application is an important criterion when selecting the appropriate type of base oil. Gear oils based on mineral oil are not suitable for permanent temperatures exceeding 90°C, as they will age at these high temperatures even with the inclusion of additives designed to combat this.

It is generally assumed that a temperature increase of 10°C reduces the oil's service life by half. Synthetic oils, however, have the advantage of built-in stability against oxidation and ageing compared with mineral oils at the same high temperatures. Because of the extended service life of synthetic or semi-synthetic products, usage can be reduced, leading to improved efficiency.



A major advantage of synthetic gear oils is extended service life

Power loss

The higher the power loss in a gear, the lower the efficiency. The power loss is caused by load-dependent and load-independent friction losses in the gears, bearings and seals or by losses in the couplings, fans and oil pumps. A decrease in temperature leads to a reduction in power loss, and so improves efficiency.

Therefore, by using gear oils with PD characteristics, you can achieve either a higher output power at a constant input power or a constant output power at a reduced input power – delivering potential energy savings.

The efficiency of a gear can be calculated using this equation and is based on the ratio of input power to output power

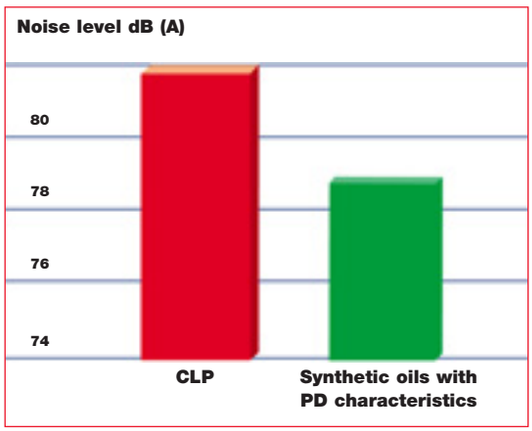
$$\eta = \frac{P_{ab}}{P_{an}} = \frac{P_{an} - P_v}{P_{an}}$$

η = **Efficiency**
P_{an} = **Input power**
P_{ab} = **Output power**
P_v = **Power loss**

Noise emission test

Gear rig tests demonstrate the noise reduction achieved with gear oils featuring PD additives. Depending on the performance of the test gear, reductions of 2 to 3 dB(A) can be measured.

A reduction of 3 dB(A) can mean up to a 50% reduction in noise level for the operator. One reason for this dramatic noise reduction is that smoothed surfaces produce less vibration during gear operation. Another reason is the temperature reduction achieved with gear oils containing PD additives, compared with conventional (CLP) gear oils. At lower temperatures, PD-containing oils have a higher viscosity and form a thicker lubricating film, which has a better resilience to vibrations.



Smoother surfaces and lower temperatures reduce the noise of gear units

Miscibility

In principle, mineral oils and polyalphaolefins are fully miscible (as are ester based products). However, to fully profit from the efficiency of gear oils with PD characteristics, we recommend when converting from a conventional gear oil to allow a maximum of 3% residual volume – or ideally avoid this completely.

The gear oils described here should, however, never be mixed with gear oils based on polyglycols. If the gear was previously filled with a polyglycol, we recommend cleaning with a special flushing oil before refilling the gear.

More information about the properties and advantages of high performance lubricants with PD characteristics is available in our Plastic Deformation brochure.

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