

ENHANCED OPEN GEAR LUBRICANTS PROVIDE TANGIBLE BENEFITS FOR HEAVY INDUSTRY – THEY ARE THE 'CLEAR' CHOICE FOR IMPROVED OPEN GEAR RELIABILITY

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ABSTRACT

The maintenance of large open gear systems at mines, power or cement plants present a significant challenge due to the heavy loads and harsh environmental conditions. Common lubrication issues include housekeeping, excessive energy consumption and maintenance issues due to a build-up of hardened lubricant in the roots of the gears.

Since the late 1980's a range of new, improved enhanced lubricants were developed in order to address these problems and allow mines or cement plants to reduce their maintenance and operating costs for ball mills and kilns. Since their introduction, these lubricants have established a proven record of providing superior lubrication and wear protection for large open gears.

Following are nine specific benefits from converting open gears to enhanced lubricants:

1. Proprietary Anti-Wear Additives

These additives provide outstanding wear protection and prevent any possible metal-to-metal contact between the gears.

2. Gear Healing Solution

Many large open gears experience damage over time – scoring, pitting or spalling can roughen the gear tooth contact area. High-performance lubricants provide a healing solution to this expensive maintenance problem.

3. Better Gear Protection

Asphaltic-based compounds typically have Timken OK Load ratings of 20 to 25 pounds, and so they must be used in excessive quantities to provide adequate protection. The Timken ratings for enhanced lubricants exceed 90 pounds.

4. Easy Visual Inspection

Applied to open gears, several enhanced lubricants appear clear enough to see through, which makes it easy for maintenance personnel to inspect the surface of the gears by using a strobe light while the mills continue to work. No cleaning or downtime is required for inspection, thus reducing maintenance and operating costs.

5. Faster, Safer Cleanup

Cleanup and other housekeeping associated with the use of asphaltic-based products can be time-consuming & expensive. Typically, a much smaller quantity of lubricant is now required to provide far superior, less messy gear protection. Ultimately, housekeeping is improved.

6. Less Energy Consumption

The annual electricity cost of ball mills & kilns is a major overhead cost for industrial plants. Due to the superior lubricating qualities of these new lubricants, plants can experience up to a 3% reduction in electrical costs.

7. No More Hazardous Waste

These lubricants can be treated as an ordinary lubricant and can often be added to the fuel or coal burned in the normal operation of many plants.

8. Simple Conversion Process – no downtime required

Converting open gears to Pyroshield lubricants is simple using a proven, effective and safe procedure that does not interrupt production or operation. Effective cleaning and lubricant protection of the gear system occurs throughout the process.

9. Lower Lubrication Costs

Although high-performance enhanced lubricants cost more initially than the alternatives, the resulting reduction in lubricant & electrical consumption leads to an overall reduction in lubrication costs.

Enhanced lubricants can improve bottom line profits and return on net assets by improving the reliability of open gears & by reducing their maintenance. Like Pyroshield, the choice should be clear.

Keywords: Anti-wear, Energy consumption, Open Gear, (maximum 5 keywords)

NONMENCLATURE LIST

Abbreviation

SAIT	South African Institute of Tribology
ITC	International Tribology Council
LE	Lubrication Engineers

1. INTRODUCTION

The maintenance of the large open gear systems at industrial sites such as mines & cement plants presents a significant challenge due to the heavy loads and harsh environmental conditions. Common lubrication issues include housekeeping due to the large quantity of lubricant that is traditionally required to provide a continuous coating to the open gears. In addition, when asphaltic products are in use for many years, the result is a build-up of hardened lubricant in the roots of the gears. This presents many problems with cleaning and mechanical interference that can result in gear misalignment or stress on the pedestal mountings. Since the late 1980's a range of new, improved enhanced lubricants were developed in order to address these problems and allow mines and cement plants to reduce their maintenance and operating costs for their critical ball mills and kilns. Since their introduction, these lubricants have established a proven record of providing superior lubrication, wear protection & operational savings for large open gears. This paper outlines the nine key features & benefits of converting critical open gear applications to enhanced lubricant technology.

2. PAPER STRUCTURE

2.1 Proprietary anti-wear additives

Solid film additives such as the well-known molybdenum disulfide or graphite were traditionally the most common form of anti-wear protection used in open gear lubricants. However they had a number of disadvantages which included a tendency to build up on themselves which could then affect machinery with close tolerances. For open gears this could result in a build-up of product in the roots of the gear teeth that solidified over time – difficult to clean and remove as well as creating mechanical interference. However another type of solid film additive has been available for more than fifty years and integrated into specially developed open gear lubricants in the late 1980's. Metallic oxide type additives such as ALMASOL® provide thin film lubrication protection to the gears due to the fact that they can resist loads of more than 400,000psi (28,123 kgf/cm²) and temperatures in excess of 1,000°C. These extreme temperatures and load levels are found at the microscopic asperity level found on all metal gear teeth and additives such as ALMASOL prevent any possible metal to metal contact between the gears and act like a very thin but powerful glove of anti-wear protection around the metal surfaces. Finally and importantly metallic oxide type additives do not build up on themselves due to the fact that the technology has a natural affinity with metal surfaces but repels itself. The immediate & tangible result of such additives is a reduction in the operating temperature of the gear teeth once the new enhanced lubricant has been applied via the auto lubrication system.

Table 1 Metallic Oxide type anti-wear additives outperform conventional solid additives

Solid Additive	Maximum Service Temperature	Load Carrying Capacity	Acid Resistance	Drawbacks when used in industrial lubricants
Almasol®	1,038°C	400,000psi 28,123kgf/cm ²	Inert	None
Molybdenum Disulfide	343°C	400,000psi 28,123kgf/cm ²	Some	Oxidises in air above 343C (650F) forming abrasive molybdenum trioxide. Tendency to build up on itself, affecting machinery with close tolerances. Cannot tolerate hydrochloric and nitric acids, especially when heat, water and air are present.
Graphite	426°C	80,000psi 5,625kgf/cm ²	Some	Known to exhibit galvanic corrosion problems. Tendency to build up on itself, affecting machinery with close tolerances.
Fluorocarbon (PTFE)	260°C	5,000psi 352kgf/cm ²	Inert	No load-carrying capability. Tendency to build up on itself, affecting machinery with close tolerances.

2.2 Superior Gear Protection

Due to shock loading it is common for heavily loaded open gears to be damaged due to inadequate protection from the lubricant in use. Asphaltic-based compounds have typically only had a Timken OK Load rating of 20 to 25 pounds and they have therefore had to be used in excessive quantities in order to provide sufficient protection to gears. However, the Timken OK Load ratings of new, enhanced lubricants generally exceed 60 pounds and some synthetic lubricants such as PYROSHIELD achieve results as high as 90 pounds.

Comparison of Important Characteristics of Lubrication Engineers Pyroshield 9011 and 9000 with Typical Asphalt-Type Open Gear Lube

Property	9011 Pyroshield XH	9000 Pyroshield	Typical Asphaltic Lube	Observations
Color	Purple, Transparent	Purple, Transparent	Black	Pyroshield allows inspection of gear surfaces with a strobe light while the gear is running.
Appearance	Viscous, Liquid	Viscous, Liquid	Liquid or Semi-Fluid Grease	
Diluent Content, %	8	-	13 to 30	Pyroshield has a <u>higher lubricant content</u> .
Asphalt Content, %	0	0	35-50	Pyroshield base stock is <u>100% synthetic</u>
Copper Corrosion	1B	1B	2B	Pyroshield is <u>not corrosive</u>
4 Ball, Weld, Kg	400	400	400	Pyroshield provides superior <u>extreme pressure protection</u> .
Load Wear Index	95	95	70	Pyroshield provides <u>superior wear protection</u> .
Timken OK Load, Lbs	95	95	45	Pyroshield has <u>superior load carrying ability</u> .
FZG	Pass 14 Stages	Pass 14 Stages	Pass 12 Stages	Pyroshield has <u>superior load carrying ability</u> .
Rust, 24 Hrs. @ 60°C	Pass	Pass	Pass	
Viscosity w/o diluent (SUS@210°F)	5,149	880	2,800 to 6,200*	Pyroshield has a <u>much higher base viscosity</u> at the operating temperature, which provides a <u>thicker oil film</u> separating metal surfaces.
Viscosity w/o diluent (SUS@104°F)	187,500	150,700	10,000 to 30,000*	
Viscosity w/o diluent (cSt@40° C)	36,070	28,980	5,000 to 10000*	
Viscosity with diluent (cSt@40°C)	6,000	-	150 to 8,000	9011 Pyroshield has enough diluent to make it easily sprayable, but remains viscous enough to provide a thick oil film.
Viscosity with diluent (SUS@104°F)	31,200	-	800 to 30,000	

Figure 1 Comparison of enhanced lubricant gear protection characteristics with a typical asphalt-type open gear lubricant

2.3 Gear Healing Solution

Many large open gears experience damage over time – scoring, pitting or spalling can roughen the gear tooth contact area. High-performance lubricants provide a healing solution to this expensive maintenance problem. The healing process begins with a redistribution of the load over the surface area of the gears, made possible by high film strength and film thickness. Pyroshield's

ability to keep the gears separated and not allow asperities and high points to come into contact allows the nondestructive deformation of the gear surface, which ultimately results in healed gear appearance. Often small pits will close up completely and disappear due to this deformation of the gear surface. The photographs of the gear teeth in Figure 1 at a cement plant in Halkis, Greece, are just one example of gear healing that substantially increased open gear life and reduced maintenance costs for the customer Titan Cement.

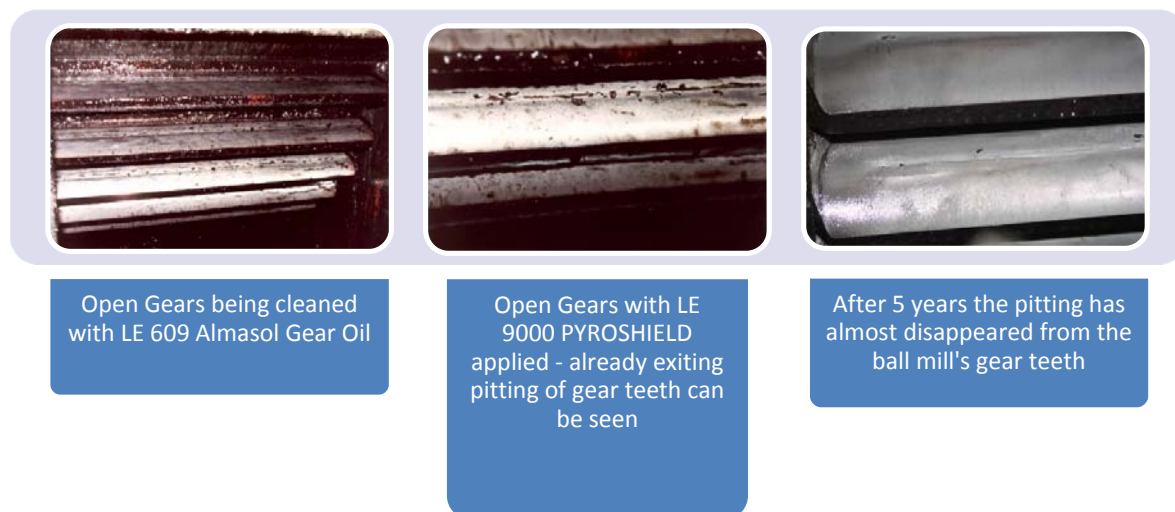


Figure 2 Gear Healing solution on ball mill open gears at Titan Cement, Halkis, Greece

2.4 Less energy consumption

The annual electricity cost of open gear applications such as ball mills is one of the biggest operating costs for industrial plants such as mines. Due to the previously outlined superior anti-wear and lubricating qualities of enhanced lubricants it is normal for significant energy savings to be achieved due to the fact that metal to metal contact has been reduced and therefore so have friction, heat & wear. The source of heat in an open gear set is friction and when this friction is reduced it means that less energy is required to overcome that friction. Enhanced lubricants enable substantial open gear temperature reductions to be achieved, sometime in excess of 15°C during the conversion process and continuing during normal operation. Importantly the Delta T across the face of the pinion gears is also reduced demonstrating that there is improved distribution of load. Despite varying loads on the equipment customers are able to analyse longer term energy trends as well as the productivity of mills and kilns in order to assess energy savings. Some mines in South Africa have recorded a reduction in energy consumption of approximately 400Kw-600kW or approximately twelve percent on mill motors whilst still maintaining the same production output. A South African platinum mine recorded a reduced power consumption on each of their 2500kw mills of up to 200kw.

2.5 Lower lubrication costs

Although high-performance enhanced lubricants cost more initially than alternative commercial type lubricants, the resulting reduction in lubricant consumption leads to an overall reduction in lubrication costs. Cement plants & mines regularly experience lubricant consumption reductions of more than 80% when they convert their open gears to PYROSHIELD Open Gear Lubricants. These reductions in consumption quantities alone normally more than justify the initial higher purchasing price. One Bulgarian cement plant's estimated savings due to consumption reduction were €86,904 – this did not take into account other important cost-reducing factors such as reduced energy consumption & lubricant disposal costs, longer equipment life, cleaner working environment and ease of inspection. A South African platinum mine was able to reduce their lubricant consumption from 800kg per month down to only 80kg per month – equating to a ninety percent reduction in lubricant consumption.

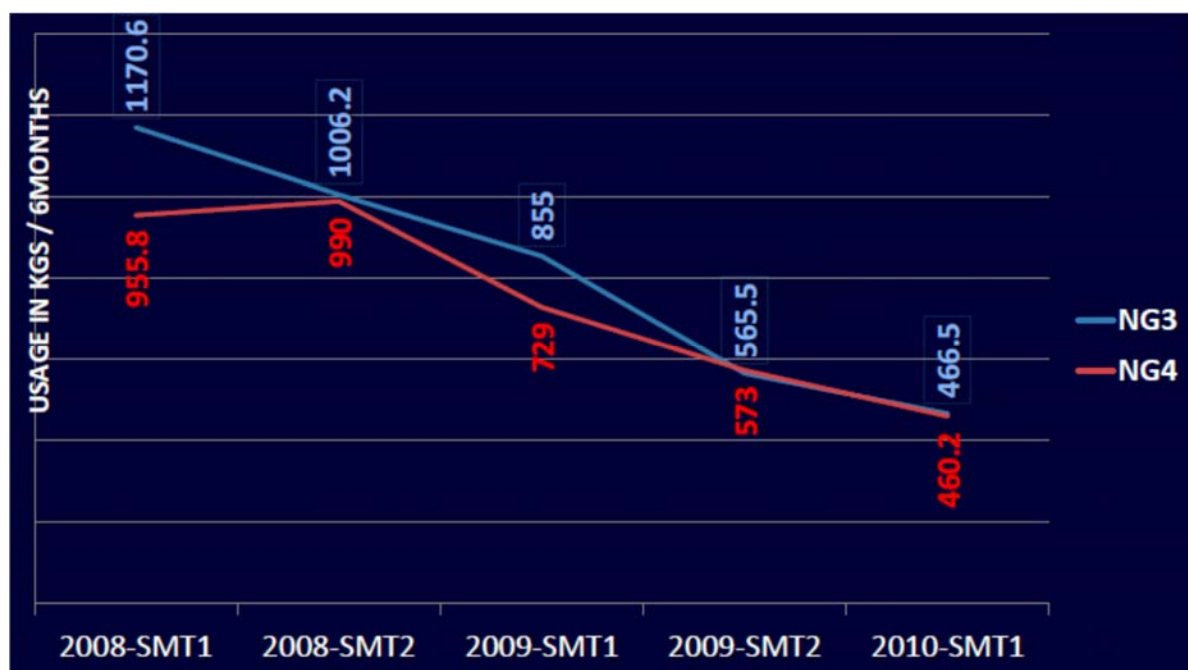


Figure 3 Reduction in consumption of enhanced open gear lubricant for two kilns at Indonesian cement plant

2.6 No more hazardous waste

Enhanced lubricants such as PYROSHIELD can be treated as an ordinary lubricant and can often be added to the fuel or coal burned in the normal operation of many plants. However, many asphaltic compounds contain lead or other heavy metal compounds as extreme pressure additives, contributing to their designation as hazardous waste products. The asphaltic compounds could also contain polycyclic aromatic hydrocarbons that require disposal as hazardous waste. Hazardous waste disposal is expensive and it necessitates tedious cradle-to-grave record keeping. A cement plant in Bulgaria dramatically reduced its disposal costs by converting its two KHD kilns and two of its Polysius ball mills to PYROSHIELD. The waste reduction was 600kg per kiln alone – a tonne less hazardous waste to dispose of annually. The reduction for its two ball mills using PYROSHIELD was even greater – nearly 1,800 Kg per mill. With a total of nineteen fewer drums of hazardous waste to dispose of each year at an approximate cost of €350 per drum, the plant experienced a total saving of €6,650. The previously mentioned platinum mine’s ninety percent reduction in lubricant consumption meant that the mine was no longer having to dispose of large volumes of used lubricant which then assisted their carbon reduction targets. An Indonesian cement plant was able to reduce its disposal costs by reducing open gear lubricant consumption from 6kg per day down to 1.4kg per day – a seventy seven percent reduction.

2.7 Faster, safer cleanup

Cleanup and other housekeeping associated with the use of asphaltic-based products can be time-consuming and expensive. Although total costs are difficult to estimate, operators have reported labour requirements in excess of four man-days to clean some units. In addition, the large amount of lubricant that is generally used creates build-up around the shrouds, which creates a messy, sticky, potentially unsafe work environment. However with the current enhanced synthetic lubricants such as PYROSHIELD the lower application quantities mean that open gear housekeeping is significantly improved. The cement plant in Halkis, Greece reduced its annual open gear lubricant consumption in its six ball mills by an impressive eighty seven percent - from 7,200kg to only 960kg by converting all six mills to PYROSHIELD. An additional safety point that is regularly mentioned by plants is that after the conversion of their open gears to enhanced lubricants there is also a noticeable reduction in noise levels around their mills & kilns due to the improved lubrication and reduction of metal to metal contact. This reduction in noise tends to match the ZERO HARM philosophy of industrial plants such as mines.

2.8 Simple open gear conversion process

Downtime for large cement plants & mines is expensive and important to be avoided. Converting large open gears to enhanced lubricants such as PYROSHIELD does not involve any interruption to production or operation. It is a seamless operation with effective cleaning and wear protection of the gear system throughout the conversion process. Local lubricant consultants are able to assist plant maintenance personnel with the process as well as providing detailed conversion reports. A key element of the process is the regular recording of the temperature of the gear face at a number of specified points as per Figure 2 below. As previously explained the conversion of an open gear to an enhanced lubricant normally involves a dramatic drop in the temperature of the gear surfaces due to the superior anti-wear protection and lubrication that the new lubricant provides the open gears. As long as those temperatures continue to drop or remain stable at a lower temperature it is then clear that sufficient lubrication is being provided.

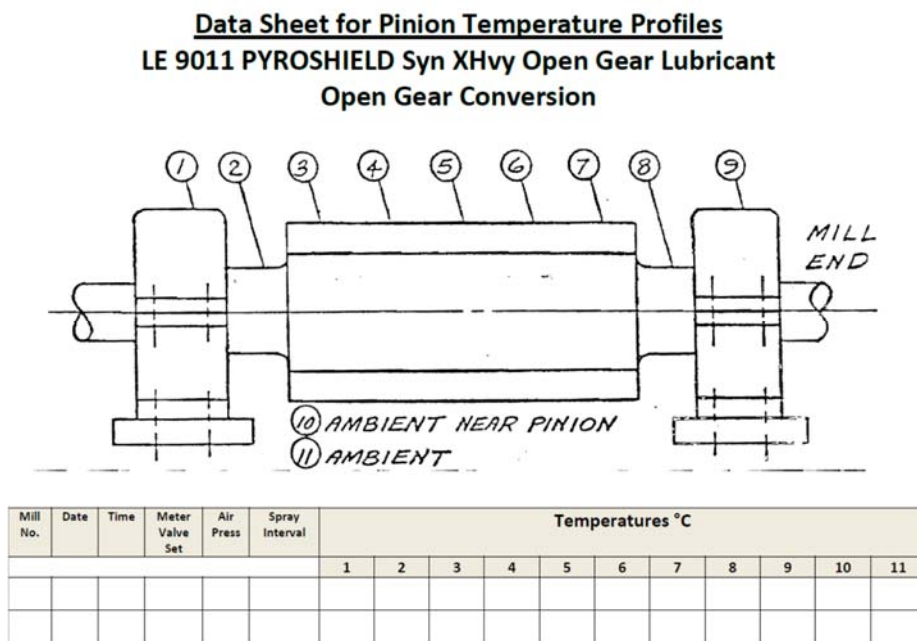


Figure 4 Recording of gear surface temperatures is an important part of the open gear conversion process

2.9 Easy visual inspection

A final major benefit of the new generation of synthetic enhanced lubricants is that several of them are translucent when applied to open gears. The lubricant is actually clear and this makes it easy for maintenance personnel to inspect the surface of gears by using a strobe light while the mills continue to work. No cleaning or expensive downtime is required for periodic gear inspection thereby once again further reducing maintenance & operating costs for the plant in question. It is this translucence that has enabled certain customers to understand how & when the gear healing phenomenon starts to occur – they are actually able to see that wear & pitting starts to disappear over a longer period of time as per the images in Figure 2.

3. CONCLUSIONS

Enhanced lubricants have been proven in the field for nearly thirty years to offer companies improved profits and return on net assets by increasing the reliability and productivity of open gears whilst reducing the costs of operating and maintaining them. As the cost of energy to industry continues to rise, these superior lubricants are also able to offer significant savings by considerably reducing the generally high levels of open gear energy consumption. The conversion of open gears to enhanced lubricants is a win/win scenario for maintenance personnel, financial officers as well as companies’ environmental credentials – like the lubricants themselves the choice should be clear.