

*The Lubrication Reliability Source™*



# Enhanced Open Gear Lubricants – Providing Tangible Benefits for Heavy Industry



SAIT Tribology  
2015, Pretoria,  
South Africa

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***LUBRICATION  
ENGINEERS, Inc.***

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## Abstract

The maintenance of large open gear systems at mines, power or cement plants can be difficult due to the heavy loads and harsh environmental conditions. Common challenges include excessive energy consumption, housekeeping, and the buildup of hardened lubricant in the roots of the gears.

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





# Enhanced Lubricants

## Benefits

1. Proprietary anti-wear additives
2. Superior protection
3. Gear healing solution
4. Less energy consumption
5. Lower lubrication costs
6. No more hazardous waste
7. Safer, faster cleanup
8. Easy visual inspection
9. Simple conversion process



## Industry Overview

- Many industries require material to be pulverized or ground. The equipment doing this work uses large open gear systems to drive the equipment.
- The common denominator is large open gearing used to drive the machinery.

Harsh conditions include:

- Outdoor environment
- Heavy & shock loading conditions
- Cement /mineral dusts
- Extreme heat (kiln)

The conditions magnify the need for superior lubricating products.

Due to the operational state and nature of the equipment, a continuous coating of lubricant is needed for the gears.





# Mining

## Common Equipment Types with Large Open Gears

- Autogenous Grinding
- Semi-Autogenous Grinding
- Ball Mill

*Autogenous* means produced from within; self-generating (media). Autogenous mills operate mechanically, like ball mills.

Both types of mills operate in wet or dry grinding conditions. Autogenous mills use large particles of ore instead of steel balls as the media for breaking and grinding the ore.



Copper Mine  
Semi-Autogenous

In mining, the grinding of the material (after extraction) takes place in autogenous or semi-autogenous mills. Due to the harsh conditions, these mills are ideal candidates to benefit from enhanced lubricants.



# Cement

## Common Equipment Types with Large Open Gears

- Raw Mills / Grinding
- Finish Mills / Grinding
- Kilns

Most cement facilities require materials to be ground or pulverized for use in the manufacturing process. Much of this material is ground in ball, pebble, rod or breaker mills. Many of these mills have large, open bull or ring gear and pinion gear sets as drive mechanisms.





# Power Generation

## Common Equipment Types with Large Open Gears in Coal Operations

- Ball Mills

Coal power plants crush large amounts of coal into powder to use in furnaces. They also grind limestone for scrubber units.

Coal-Fired Power Plant • Asturias, Spain  
Narcea & HC Energia  
Foster Wheeler Ball Mills



Coal-Fired Power Plant  
Pennsylvania  
Foster Wheeler Ball Mills



This pinion is more than 10 years old. The mill was running when the photo was taken. Note the excellent condition of the gear and the lack of accumulated product.

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# Benefits of Enhanced Open Gear Lubricants

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# Open Gear Lubricants

## Characteristics

- Fluid
- Grease

## Differentiation

### Fluid Products

- Shrouded Gears

### Grease Products

- Unshrouded gears
- Horizontal position gears



## Open Gear Lube Selection:

- Blackjack – Asphaltic compounds
  - ✓ Mostly replaced Mobil & Whitmore
- European style – Fluid greases
  - ✓ Light viscosity base oils / solid additives
  - ✓ Kluber, Fuchs, Addinol
- Heavy viscosity synthetic gear oils – 36,000 cSt
  - ✓ LE, Mobil, Kluber
- Combination fluid grease / synthetic oil
  - ✓ Shell, Whitmore, Castrol

### What are the features & benefits of enhanced open gear lubricants?

1. Proprietary anti-wear additive
2. Superior gear protection
3. Gear healing solution
4. Less energy consumption
5. Lower lubrication costs
6. No more hazardous waste
7. Faster, safer cleanup
8. Simple open gear conversion process
9. Easy visual inspection




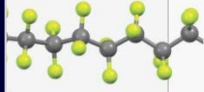


# Enhanced Lubricants

## 1. Proprietary Anti-Wear Additive

### Almasol® Outperforms Conventional Additives

- Solid anti-wear additives used traditionally in open gear lubricants have disadvantages, including:
  - ✓ Tendency to build up on themselves & affect machine tolerances
  - ✓ Tendency to accumulate in the roots of gear teeth & solidify over time, making cleaning difficult

Solid Additive	Maximum Service Temperature	Load Carrying Capacity	Acid Resistance	Drawbacks When Used in Industrial Lubricants
 <b>Almasol®</b>	1,038°C (1,900°F)	400,000 psi (28,123 kgf/cm <sup>2</sup> )	Inert	None
 <b>Molybdenum Disulfide</b>	343°C (650°F)	400,000 psi (28,123 kgf/cm <sup>2</sup> )	Some	Oxidizes in air above 343°C (650°F), forming abrasive molybdenum trioxide. Tendency to build up on itself, affecting machinery with close tolerances. Cannot tolerate hydrochloric and nitric acid, especially when heat, water and air are present.
 <b>Graphite</b>	426°C (800°F)	80,000 psi (5,625 kgf/cm <sup>2</sup> )	Some	Known to exhibit galvanic corrosion problems. Tendency to build up on itself, affecting machinery with close tolerances.
 <b>Fluorocarbon (PTFE)</b>	260°C (500°F)	5,000 psi (352 kgf/cm <sup>2</sup> )	Inert	No load-carrying capability. Tendency to build up on itself, affecting machinery with close tolerances.

## Enhanced Lubricants

### 1. Proprietary Anti-Wear Additive

#### Almasol® Withstands High Temps & Heavy Loads

*Solid film additive ...*

- Withstands temperatures up to **1,038°C (1,900°F)**
- Withstands heavy loads of up to 400,000 psi (28,123 kgf/cm<sup>2</sup>)
- Provides AW & EP protection
- Reduces friction & energy
- Deposits sacrificial layer on metal surfaces
- Will not build up on itself
- Remains stable even in extreme heat





## Enhanced Lubricants

### 2. Superior Gear Protection

#### What's the difference in Timken OK load?

##### Conventional Lubricants

- Asphaltic-based lubricants typically have a Timken OK Load rating of **20-25 lb.**
- Therefore, they are used in excessive quantities to provide sufficient protection to gears.

##### Enhanced Lubricants

- Enhanced open gear lubricants generally have Timken OK Load rating that exceeds **60 lb.** Some synthetic open gear lubricants achieve results as high as 90 lb.
- These figures confirm that enhanced lubricants provide superior load-carrying ability.

# Enhanced Lubricants

## 2. Superior Gear Protection

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 9,000	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	



# Enhanced Lubricants

## 2. Superior Gear Protection (EP)

### FZG & SRV Tests

#### Conventional Lubricants

- Most of these lubricants indicate a 12<sup>th</sup> Stage Pass for the FZG Test.

**From:** Michaelis, Klaus Dr. [mailto:michaelis@fzg.mw.tum.de]  
**Sent:** Thursday, July 06, 2006 3:59 AM  
**To:** Sander, John  
**Subject:** AW: FZG Testing

Dear John,

we have the result of the FZG test A/8,3/90 with extended load stages 13 and 14 with your sample 9011:  
PASS in load stage 14 with light scratches on all pinion flanks.

We will prepare our official report of the test and send it together with our invoice to your attention.

If you have further questions please let us know.

Best regards

Klaus

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#### Enhanced Lubricants

- The SRV & FZG tests closely represent real world performance.
- The FZG test uses actual gears. It represents gear performance in operating conditions similar to what a customer will experience. Enhanced lubricant data shows a very robust wear rating (**14<sup>th</sup> Stage Pass**).
- The SRV test is a point contact test, like the 4-ball EP test, but it uses vibration. Not many lubrication companies have the technical equipment to perform this test. The SRV data for enhanced lubes show great wear properties (**1,200 result**).

### 3. Gear Healing Solution

#### *Problem?*

- When an open gear is damaged, the surface of the gear tooth contact area is roughened by scoring, pitting & spalling.
- Removal of the metal causes areas of higher stress & loading on the open gears, which over time increases the wear & damage to the gear teeth.



#### *Solution?*



- The use of a high-performance open gear lubricant can help 'heal' the gear surface.
- The high film strength & film thickness of the lubricant redistributes the load over the surface area of gears.
- The lubricant's ability to keep the gears separated and not allow asperities and high points to come into contact allows nondestructive deformation of gear surface.
- This redistribution of load ultimately evens out to a point of equilibrium and results in the healed gear appearance.
- Small pits often close up completely.



## Enhanced Lubricants

### 3. Gear Healing Solution

#### Ball mill open gears at Titan Cement, Halkis, Greece



Open gears being cleaned with LE's Industrial EP Gear Oil



Open gears with LE's Pyroshield applied – the already existing pitting of the gear teeth can be clearly seen.



After 5 years, the pitting has almost disappeared from the ball mill's gear teeth.

## Enhanced Lubricants

### 3. Gear Healing Solution

Kiln open gears at Arrium Mine Pellet Plant, Australia

*December 2014*



*February 2015*

Note: Plastic flow has occurred, reducing the depth & size of damaged area.



# Enhanced Lubricants

## 3. Gear Healing Solution

### Side A – North Side Pinion Inspection Report – Comparison

*July 2014*



*February 2015*



Note: Reduction in depth  
and size of the gouging



# Enhanced Lubricants

## 4. Less Energy Consumption

Substantial energy savings are available



### *Problem*

- Annual electricity cost of open gear applications is one of largest operating costs for industrial plants such as mines.
- Ball mills & kilns often work 24/7 & require huge amounts of electricity to drive them.



### *Solution*

- Converting open gears to enhanced lubricants helps achieve significant savings in electrical consumption.

### *How?*

- Due to superior gear protection, metal-to-metal contact is reduced, resulting in less friction, heat & wear.
- The source of heat is friction; when this is reduced, less energy is required to overcome the friction.
- Temperature reductions of  $>15^{\circ}\text{C}$  are achieved during conversion process.

## Enhanced Lubricants

### 4. Less Energy Consumption

#### Case Study



#### Lonmin Platinum, Limpopo, South Africa

- Reduced power consumption by **200 kw** on each of their 2500kw ball mills after converting to an enhanced open gear lubricant
- ABB measured a vibration reduction on the pinion of up to 15%.

#### Case Study



#### Impala Platinum, Rustenberg, South Africa

- Prior to converting their ball mill to an enhanced lubricant, their mill drive motor historically operated between:  
*5.6MW & 5.4MW*
- After the conversion, it operates at:  
*4.8 to 5MW*
- Preliminary results suggest significant reduction in energy consumption of **400 kw – 600 kw**, or approximately **12%** on the mill motor while maintaining the same production output.

# Enhanced Lubricants

## 4. Less Energy Consumption

### Case Study



#### Titania Telles Mine, Norway

- Energy consumption for their Nordberg Mills **reduced by 10%** since converting them to an enhanced lubricant in 1997.



### Case Study

**lundin mining**

#### Candelaria Mine, Chile

- Converted their Svedala Mill #3 in 2007 to an enhanced lubricant.
- Reduced operating temperature of pinion from 74°C to 54°C at the middle point
- This significant temp reduction equates to an approximate **5% energy saving**.





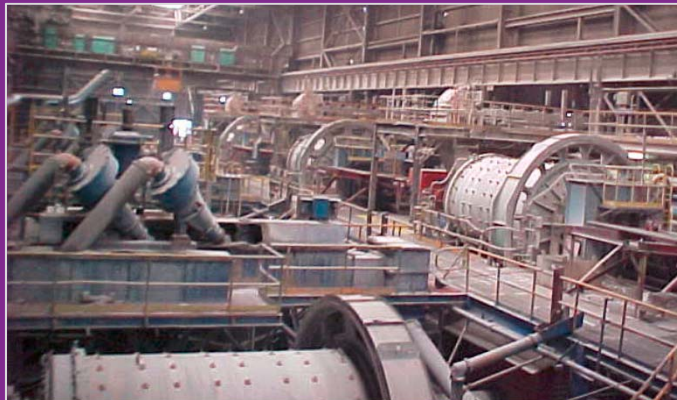
# Enhanced Lubricants

## 4. Less Energy Consumption

### Case Study

#### Codelco Salvador Mine, Chile

- Converted a rod mill & 2 ball mills in 2005 to an enhanced lubricant.
- 8kw saving was calculated, which would equate to electricity savings of USD 2,590 and when calculated across 18 mills = USD 46,000.



#### AVERAGE POWER CONSUMPTION WITH LE PYROSHIELD 9011 AND IMPERFLUID OGLT COMPARISON ROD MILL # 30

The next table has been created based on previous and new records (figures shows down) taken from PI System Control and given to us by Mr. Mauricio Rodriguez Rodriguez from the Mill Control Room.

Average Power w/o LE (Kw)	Average Power w/ LE (Kw)	Power Saving (Kw)	Energy Cost USD/Kwhr	Annual Mill hours	Electrical Energy Consumption Savings USD/Annual Mill	Electrical Energy Savings USD/annual Section	Total Number of Mills	Total Energy Consumption Savings
516	508	8	0,037	8.749	2.589,70	7.769	18	46.415

These results confirm that with the use of PYROSHIELD 9011 you save electric energy as a result of less friction.

The Total Energy Consumption Savings of USD 46.415 (Forty six thousands and four hundred and fifteen dollars) has been valued based on generated savings on Rod Mill # 30. It is an approximate value that shows the benefits of the use of PYROSHIELD 9011 high technology in lubricants.

# Enhanced Lubricants

## 5. Lower Lubrication Costs

Reduction in lube & energy consumption leads to overall cost reduction.



### *Problem*

- High costs of using asphaltic-type open gear lubricants due to extremely high volume of lubes that are used & then disposed of.



### *Solution*

- With huge reduction in lube consumption, customers can benefit from significant reduction in lube costs.
- This is despite the initial higher purchasing price of the enhanced lubricants.
- The ROI & TCO of enhanced lubricants is improved due to:
  - *Lower lubricant consumption*
  - *Lower energy consumption*
  - *Less lubricant disposal*
  - *Less gear wear (and replacement)*
  - *Less downtime*
  - *Increase productivity*

# Enhanced Lubricants

## 5. Lower Lubrication Costs

Reduction in lube & energy consumption leads to overall cost reduction.

### Case Study



#### Lonmin Platinum, Limpopo, South Africa

- Converted 2500kw ball mills to enhanced open gear lubricant
- Reduced lube consumption by **35%** on each ball mill

### Case Study



#### Impala Platinum, Rustenberg, South Africa

- Converted ball mill to an enhanced lubricant
- Safely reduced lube consumption from 800 kg per month to only 80 kg per month
  - ✓ 90% reduction in usage
  - ✓ 8,640 kg less lubricant to dispose of
- No longer have to dispose of more than 8 tonnes of used open gear lubricant, which helps them meet their carbon reduction targets



# Enhanced Lubricants

## 5. Lower Lubrication Costs

Reduction in lube & energy consumption leads to overall cost reduction.

### Case Study



#### Escondida Copper Mine, Chile

After successful ball mill conversions to an enhanced lubricant, the mine converted their critical SAG Mill #3 to the same product:

- 775 g per hour to only 196 g per hour
  - ✓ 75% reduction in usage
  - ✓ 5,073 kg less lubricant to dispose of



### Case Study

#### Hercules Cement, Halkis, Greece

- Reduced lubricant consumption by 87%
- Total cost reduction of 30%

Before 1998, with asphaltic lubricant

- 1,200 kg of lubricant per mill per year
- 409 kg per 2,500 hours of operation

After 1998, with enhanced lubricant

- 160 kg of lubricant per mill per year
- 54.4 kg per 2,500 hours of operation
- Total annual lube consumption at 6 mills:
  - ✓ Pre 1998: 7,200 kg
  - ✓ Post 1998: 960 kg
  - ✓ 6,240 kg less lubricant to dispose of

# Enhanced Lubricants

## 5. Lower Lubrication Costs

After converting their 2 kilns to an enhanced lubricant, Holcim Indonesia experienced significant reductions in lube consumption.



## Enhanced Lubricants

### 6. No More Hazardous Waste

#### *Problem*

- Many asphaltic compounds contain lead or other heavy metal compounds such as EP additives.
- They can also contain polycyclic aromatic hydrocarbons that require disposal as hazardous waste.
- This contributes to their designation as hazardous waste products. This makes it expensive to dispose of them & requires tedious cradle-to-grave recordkeeping.

#### *Solution*



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

- Example: Bulgarian Cement Plant
- Dramatically reduced its disposal costs by converting 2 KHD kilns and 2 Polysius ball mills to an enhanced lubricant.
- Waste for kilns was reduced by 600 kg each (a tonne less per year).
- Waste for ball mills was reduced by 1,800 kg.
- In total, 19 fewer drums per year @ €350 per drum = **€6,650 per year savings.**



# Enhanced Lubricants

## 7. Faster, Safer Cleanup



### *Problem*

- With asphaltic type lubricants, excess lubricant builds up in the shrouds, which creates messy, sticky & potentially unsafe work environment.
- Operators have reported labour requirements of >4 days to clean open gears

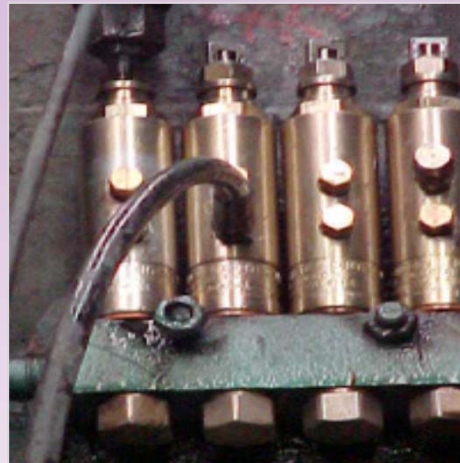


### *Solution*

- With enhanced lubricants, open gears are cleaner & do not require cleaning to inspect the gears.
- An additional safety point regularly mentioned by plants that have converted to enhanced lubricants is the ***noticeable reduction in noise levels*** around their mills and kilns due to the improved lubrication and reduction of metal-to-metal contact.
- Lonmin Platinum in Limpopo, South Africa, commented on this noise reduction factor as it matches their *ZERO HARM* philosophy.

## Enhanced Lubricants

### 7. Faster, Safer Cleanup (Automatic Spray Systems)



#### Automatic spray systems

- Manufactured by Farval, Bijur-Delimon and SKF/Lincoln
- Apply lubricants to the bull or ring gear teeth at set intervals in metered amounts.

#### Lube system improvements

- No clogging
- No solids to block or abrade measuring valves

#### Spray pattern improvements

- No clogging of nozzles
- No accumulation

### 8. Simple Open Gear Conversion Process

Eliminates expensive downtime or lost production



#### *Problem*

- Any downtime for mines or cement plants is extremely expensive and important to avoid.



#### *Solution*

- Converting open gears to enhanced lubricants does NOT require the gears to be stopped.
- It is a seamless operation with effective cleaning & wear protection of the gear system throughout the conversion process.
- A key element is the regular recording of the temperature of the gear face at a number of specified points as per the examples on following slide.
- Infrared thermometer guns are used at regular intervals to check that the temperature is remaining stable & low – meaning that sufficient lubrication exists.

# Enhanced Lubricants

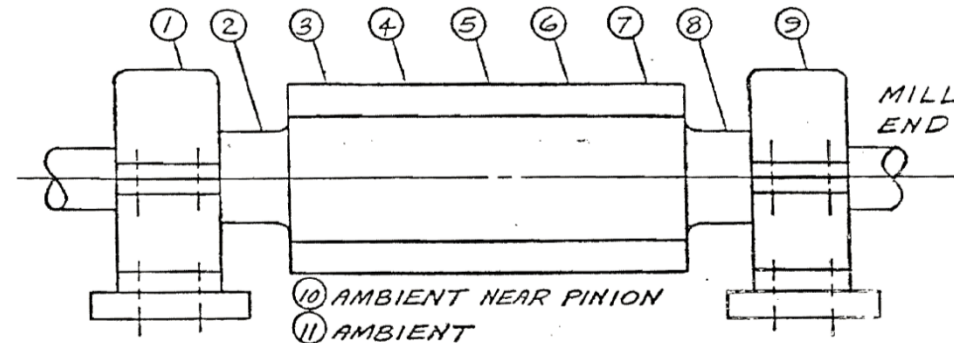
## 8. Simple Open Gear Conversion Process

### Seamless for Customers

- Production does not need to shut down during conversion
- LE provides support for conversion & monthly audits
- Customers receive follow-up, including engineering service report, after conversion



**Data Sheet for Pinion Temperature Profiles**  
**LE 9011 PYROSHIELD Syn XHvy Open Gear Lubricant**  
**Open Gear Conversion**



Mill No.	Date	Time	Meter Valve Set	Air Press	Spray Interval	Temperatures °C															
						1	2	3	4	5	6	7	8	9	10	11					



# Enhanced Lubricants

## 9. Easy Visual Inspection

Translucent lubricant enables viewing while gears are running.



### *Problem*

- Asphaltic type lubricants are dark and opaque. They do not enable customers to inspect the condition of their open gears.



### *Solution*

- Several enhanced lubricants are translucent (clear / transparent) when they are on the gears, meaning that the gear surface can be inspected with the aid of a strobe light during operation.
- No cleaning or downtime is required for periodic gear inspection, thereby further reducing maintenance & operating costs.



## Enhanced Lubricants

### 9. Easy Visual Inspection

**Pinion Gear with  
Asphaltic Type Lube**



**BEFORE  
Pyroshield  
Application**

**Pinion Gear with  
Enhanced Lubricant**



**AFTER  
Pyroshield  
Application**

# Enhanced Lubricants

## 9. Easy Visual Inspection

Pinion Gears with Asphaltic Type Lube



**BEFORE**



Pinion Gears with Enhanced Lubricant



**AFTER**





## Enhanced Lubricants

### 9. Easy Visual Inspection



Great Salt Lake Minerals  
Ogden, Utah  
Ball Mill

Soda Ash Plant  
Southwest Wyoming  
Svedala Rod Mill





## Summary

### Features & benefits of enhanced open gear lubricants

1. Proprietary anti-wear additive
2. Superior gear protection
3. Gear healing solution
4. Less energy consumption
5. Lower lubrication costs
6. No more hazardous waste
7. Faster, safer cleanup
8. Simple open gear conversion process
9. Easy visual inspection

## Conclusions

- Enhanced open gear lubricants have been proven in the field for nearly 30 years to offer companies improved profits and return on net assets by increasing the reliability and productivity of open gears while 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**.

*The Lubrication Reliability Source™*



*Thank you for this  
opportunity and for your attention.*

*Any questions, please?*

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