Meeting Industrial Gear Oil Challenges with Additive Technology

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Agenda

- Trends and challenges of industrial gear oil market
- How have the evolving OEM requirements driven industrial gear oil performances?
- Next generation additive technology to address the challenges
Industrial Gear Oil Market Drivers & Trends

**KEY MARKET DRIVERS**

- Manufacturing migration
- OEM influence & specs driven by field challenges
- Shift in base oils (growing use of Group II / III)
- Growth in energy demand
- Health, Safety and Environment

**KEY MARKET TRENDS**

- Reliability
  - Strong focus on seal compatibility
- Efficiency
- Durability
  - Extended equipment life and ODI
- Increased productivity
  - Increased power density
- Total cost of ownership
- Specialized fluid requirements
What Will Drive Gear Technology and Lubrication?

**Applications**
- Growing wind turbine
- Growing food & beverage
- Growing robotics
- Noise, Vibration, Harshness
- OSHA regulation
- Power density
- Efficiency
- Upttime operation

**Industry 4.0**
- Smart Factory
  - Competition gear drive vs magnetic drive
- Automation / Robotic
  - Growth of precision gears and gear motors
- Digitalization
  - Gearbox Monitoring
  - Reliability and lifetime of equipment and lubricants

**Materials**
- Plastic gears
- Coatings: DLC, WCC
  - 30% less friction
- Powder Metal Gears
  - High strength
  - Long wear resistance

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Industrial Gearbox Trends and Lubricants Challenges

Global/OEM Industry Trends
- Gear oil is a component of gearbox
- Challenging operating conditions (Increasing power density and Higher operating temperature)
- Smaller sump sizes
- Improved micropitting performance
- Clean gear concept
- Extended oil drain interval
- Reduced energy consumption

Challenges to Gear Oils
- Superior bearing/gear protection
- Corrosion protection
- Oxidation and thermal Stability
- Contamination control
- Excellent seal & paint compatibility
- Filterability / performance retention
- Improved foam and air release
- Improved friction
- Low temperature fluidity
Wide Applications and Challenges – Not All Industrial Gear Oils Are the Same

- **Gear Motor**
  - Gearbox: Small standard
  - Speed: High
  - Load: Constant
  - Sump size: 10 ~ 200 L
  - ODI: 0.6 ~ 2 years
  - Lubricants: Mineral Oxidation Stability

- **Roller Mill**
  - Gearbox: Large standard
  - Speed: Low
  - Load: High torque
  - Sump size: ~ 5000 L
  - ODI: 1 ~ 2 years
  - Lubricants: Mineral / Synthetic AW / EP

- **Industrial Robot**
  - Gearbox: RV / Harmonic reducer
  - Speed: High Bi-direction
  - Load: High torque
  - Sump size: 20 ~ 60 L
  - ODI: 2 ~ 3 years
  - Lubricants: Synthetic AW / EP, Friction

- **Wind Turbine**
  - Gearbox: Planetary
  - Speed: Variable speed
  - Load: Shock, High torque
  - Sump size: 400 ~ 600 L
  - ODI: 5 ~ 10 years
  - Lubricants: Synthetic Balanced AW / EP

**Applications:**
- Mining
- General Machinery
- Steel / Metal / Cement
- Power Generation / Oil / Gas
- Railway / Transport
- Mobile / Agriculture / Construction
- Others -- Wind turbine, Food, Wood, Paper, Conveyor

**Source:** Technavio Insights
End-user Insight – Afton’s Proprietary Research

Qualifications

- Maintenance personnel and engineers using industrial gear oils in industrial enclosed gearboxes
- Work full time maintaining heavy industrial machinery and accountable for fixing problems
- Deeply involved in lubricants and lubricant roles

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Gearbox Issues

- Contamination Control
- Wear Protection
- Seal Compatibility
- Viscosity Control

Gear Oil Priorities

- Contamination Control
- Wear Protection
- Seal Compatibility
- Viscosity Control
- Oxidation Control
- Extended ODI
Insight – End-user Gearbox Issues

Highest of End-user Concerns

- Oil Contamination
- Bearing Wear
- Vibration
- Overheating
- Gear Teeth Wear
- Seal Leakage
- Scuffing
- Filter Blocking

Lowest of End-user Concerns

- Noise
- Foam
- Pitting

Distilling it down:

- Wear Protection
- Contamination Control
- Viscosity Control
- Seal Compatibility
End-user Gearbox Issues and Wants from an Industrial Gear Oil

- Gearbox Issues
  - Wear Protection
    - Bearing Wear
    - Vibration
    - Gear Teeth Wear
    - Scuffing
    - Noise
    - Pitting
    - EP / Shock Load
    - Water Separation
  - Contamination Control
    - Internal & External Contaminants
    - Filter Blocking
    - Foam
  - Viscosity Control
    - Gearbox Overheating
    - Viscosity in Differing Operating Conditions
    - Viscosity at Different Temperatures
  - Seal Compatibility
    - Leakages
    - Material Compatibility
  - Oxidative Stability
    - Oxidation Properties
    - Colour Stability
  - Extended ODI
    - Longer Drain Intervals

- Wants from a new industrial gear oil

Increasing Importance
Industrial Gear Market Segmentation

Global IGO Demand: 935 KMT in 2018, growing to 988 KMT in 2027 (Kline)

- **Synthetic**
  - Improved efficiency
  - Micropitting protection & filterability
  - Dynamic seal, sealant & paints compatibility
- **Premium**
  - Additional attributes such as Clean Gear
  - Bearing wear protection, extended EP protection,
  Robust Corrosion, Static seal compatibility
- **Mainstream**
  - Entry
  - Basic Performance, Non-EP Circulating Gear

Increasing temperature, Torque, Reliability and fluid ODI

- **WT OEM:** Vestas, GE, SGRE, Goldwind
- **Gear OEM:** Winergy, ZF, NGC, Moventas
- **Bearing:** FAG, SKF, Miba
- **Standard:** IEC 61400, GB 33540.3, AGMA/AWEA 6006--A03
- **ISO 12925-1 L-CKSMP**
- **ISO 12925-1 L-CKD**
- **GB 5903 L-CKD**
- **DIN 51517-3**
- **GB 5903 L-CKC**
- **ISO 12925-1 L-CKC**
- **AGMA 9005 F16 AS**
- **AIST 224**
- **GB 5903 L-CKB**
- **ISO 12925-1 L-CKB**
- **DIN 51517-1**
- **Flened Rev. 16**
- **SEW**
- **ZF Industry**
- **Sumitomo (HIT)**
- **Eickhoff**
Key Fluid Performance Drivers – OEMs Depend on Own Specs & Approvals

**FLENDER**
Flender Rev.16 published October 2017

- FZG (A/8.3/90)
- FAG FE8 Bearing
- FVA Micropitting
- Flender foam
- Static/Dynamic seal compat
- Inner/Outer paints compat
- Sealant compatibility
- Flender Filterability

Pay attention to Energy Efficiency and Long Life / Extended Drain Interval.

**SEW**
Spec no. 07 004 03 13 released April 2016
SEW launched their own Genuine Gear Oil

- DIN 51517-3 is minimum requirement
- High focus on internal dynamic seal compatibility under most severe dynamic conditions
- FVA Micropitting

**ZF Industry**
ZFN-W-17-145 Rev.3 released in Oct. 2019
Typical “Flender” performance

- FAG FE-8 Step 1 to 4
- Wet brakes compatibility
- DGMK 377-01 wear
- SKF roller and EmCor
- ASTM D2893 Oxidation at 121°C
- Various paint compatibilities
- Many additional liquid sealing compatibilities

**Increased compatibility with non-metallic components (seals, sealant, filters & clutches)**

**Various bearing & gear tests by OEMs**

**High focus on dynamic seal compatibility**

“40% seal failures come from oil compatibility issues”

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## Gear Oil Standards – The Pace of Change is Quickening

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Industry standards continue to grow in frequency focusing on key oil performance improvement:
- Bearing wear and micropitting
- Static seal compatibility
- Environmentally friendly

Key OEMs focus own specification development on:
- Dynamic seal compatibility
- Coating compatibility
- Filterability
- Flender, SEW and ZF Industrial set the quality bar

Wind turbine gearbox OEMs (ZF Wind, Winergy and NGC) focus own specification development on:
- Bearing wear (WEC prevention)
- Multi-metals compatibility
- Foam retention after filtration
- SKF EmCor salt corrosion
# Gear Oil Specs – Key Performance Requirements

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<tr>
<th>SPEC NAME</th>
<th>AIST 224</th>
<th>AGMA 9005 F16 Antiscuff Oil</th>
<th>DIN 51517-3 CLP</th>
<th>FLENDER Rev.16</th>
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<th>ZF Industry</th>
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Next Generation IGO Additive Technology to Address the Challenges

Next Generation IGO Additive

- EP agent system optimization
- FM technology for FAG FE8 / micropitting excellence
- Robust dynamic seal compatibility chemistry technology
- Multi-metals and parts compatibility chemistry design

To meet the challenges

- SEW approval
- ZF Industrial approval
- FLENDER approval
- DIN 51517 Part 3
- ISO 12925-1 L-CKD
- GB 5903-2011 L-CKD
Wind Turbine Trends and Key Specifications for Gear Oils

Wind Turbine OEMs
- Vestas
- GE
- Siemens & Gamesa
- Goldwind

WT Gearbox OEMs
- Winergy
- NGC
- ZF Wind
- Moventas
- Eickoff
- Flender

Bearing OEMs
- Miba
- SKF
- FAG
- NSK

Industry
- GB 33540.3
- ANSI.AWEA, AGMA 6006-A03
- ISO/IEC 61400
- DIN 51517-3
- ISO 12925-1 CKSMP
Next Generation Wind Turbine Gear Oil Additive Technology

Multi-metal Compatibility
(Zinc/Yellow, Journal bearing)

Deposit control
High Temp Stability

No metals leaching from any parts and paints

Durable bearing and gear protection over 10 years ODI

Filterability and foam retention after fine filtration

SKF EmCor corrosion with salt water

Low temp fluidity
m-PAO & Ester

Wind Turbine Gearbox Failure

Bearing 70%

Gear 26%

Others 4%

How the Gear Oil Helps Prevent WEC – Afton’s Research

Based on available information, the lubricant needs to:

- Lower thin film friction (TFF) to reduce surface and subsurface stress.
- Control friction as load increases to reduce surface stress during transients.
- Form a tribofilm that is rich in Phosphorus (P) to absorb the surface stress.
- Maintain tribofilm composition as the load and sliding increase.

FAG FE8 Non-hydrogen charged testing
Industrial Robot Gear Lubrication – Market Needs a Standard

China robotics gear oil demand is surging driven by the fast-growing robotics consumption.

Operational Stock in China: Increased by 30%

Industrial Robot OEMs
• ABB
• KUKA
• FANUC
• YASKAWA

Gear Reducer OEMs
• Nabtesco
• Sumitomo
• Harmonic Drive

Industrial Robot Reducer Operating Conditions
- High friction
- Long time fatigue
- High shock load
- High operating temperature
- Long ODI
- Low temperature start
- Foam stability
- Leakage prevention

Lubricant Performance Requirements
- Anti-wear / Low friction
- Micro-pitting
- Extreme pressure
- Thermal stability
- Oxidative stability
- Low temperature performance
- Antifoam over time
- Elastomer compatibility
Thank You!

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