Introducing a Hydrolytically Stable, Low Toxicity Fire-Resistant Hydraulic Fluid for Power Stations

STLE Commercial Marketing Forum 2018

David Stonecipher
Director, Business Development
Agenda

- The New LANXESS
- Power Generation Need for Fire Resistance
- Not All Fire-Resistant Fluids Are Created Equal
- REOLUBE® Hydraulic Fluids
- Regulatory Change is Fast Approaching
- Low Toxicity REOLUBE® Hydraulic Fluid
- Summary
### LANXESS – A Global Specialty Chemicals Company

#### Specialty chemicals company
- Spin-off from Bayer in 2004
- Specialty chemicals portfolio: engineered plastics, advanced intermediates and specialty chemicals

#### Global success story
- 74 sites worldwide
- Approximately 19,200 employees in 25 countries
- Global sales of EUR ~9.72 billion in 2017

#### Strategy of profitability and resilience
- Strengthening of leading position in medium-sized markets
- Expanding global footprint
- Acquired Chemtura in April 2017
LANXESS – Lubricant Additives is a Key Growth Platform

- **Engineering Materials**
  - High Performance Materials
  - Urethane Systems

- **Advanced Intermediates**
  - Advanced Industrial Intermediates
    - Organometallics
  - Saltigo

- **Performance Chemicals**
  - Material Protection Products
  - Inorganic Pigments
  - Leather
  - Liquid Purification Technologies

- **Specialty Additives**
  - **Additives**
    - Lubricant Additives
    - Polymer Additives
  - Rhein Chemie

**Group Functions and Countries**

Business unit set up fosters dedication and entrepreneurship
Lubricant Additives – Integrated Portfolio for Wide Variety of Transportation and Industrial Applications

Overview

- **Employees:** ~ 800 worldwide
- **Production sites:** 14
- **Products:** ~ 660 different products
- **Customers:** More than 800 worldwide
- **Applications:**
  - Automotive
  - Marine
  - Aerospace & defense
  - Power Generation
  - Refrigeration
  - Metal Working
  - General Industrial

Lubricants Additives Business offers an integrated portfolio for lubricants
**Lubricant Additives – Full Value Chain Solutions**

<table>
<thead>
<tr>
<th>Synthetic Base Fluids</th>
<th>Additive Components and Packages</th>
<th>Formulated Lubricants</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Viscosity PAOs</td>
<td>Aminic Antioxidants</td>
<td>Fire-resistant Hydraulic Fluids</td>
</tr>
<tr>
<td>Specialty Esters</td>
<td>Detergents &amp; Corrosion Inhibitors</td>
<td>Refrigeration Fluids</td>
</tr>
<tr>
<td>Phosphate Esters</td>
<td>Extreme Pressure, Anti-Wear Additives</td>
<td>Aerospace &amp; Defense Fluids</td>
</tr>
<tr>
<td>Ester-Functionalized PAOs (WTP 40)</td>
<td>Water-Miscible Additives</td>
<td>General Industrial Fluids</td>
</tr>
<tr>
<td></td>
<td>Industrial Additive Packages</td>
<td>High-performance Greases</td>
</tr>
</tbody>
</table>
Lubricant Additives – Extensive Global Manufacturing, Technology and Sales Network

**Headquarters:** Middlebury, CT, USA

**Manufacturing:**
- 14 production sites in 11 countries

**Technical Competence Centers:**
- Mannheim, Germany
- Qingdao, China
- Trafford Park, UK
- Nanjing, China
- Naugatuck, CT, USA

**Regional Sales Hubs:**
- Cologne, Germany
- Pittsburgh, PA, USA
- Shanghai, China
Every year there are serious losses from fire in power stations
Reported that 75% of fires originate in turbine oil systems → 700 fires reported from 1991-2005
Further reported that 50% of these fires originate from the hydraulic system
Fire impacts
- Loss of life
- Loss of equipment
- Loss of production
It is estimated that the use of fire-resistant hydraulic fluids save 500 lives per year
The use of fire-resistant hydraulic fluids can reduce insurance premiums
Electrohydraulic Control (EHC) Systems

- EHC fluids typically are non-aqueous, and are used in power turbine control systems to govern the steam supply to the turbine generators
- The EHC system is required to react extremely quickly (milliseconds) in order to shut off steam to prevent a ‘runaway’ turbine
- A fluid leak or spray from a pressurized hydraulic system coming into contact with hot surfaces such as super-heated steam pipes is a considerable fire risk
- Steam temperatures can range from 300°C to over 600°C with ultra-supercritical power plants
- These temperatures are well above the ignition point of most hydraulic fluids – even synthetic based products
- The fluid choice needs to be made with safety in mind...
Several different types of EHC hydraulic fluids are fully approved by FM Global Group under Standard 6930 (Industrial Fluids) and carry the FM kitemark
- Phosphate esters
- Polyol esters
- Polyalkylene glycols (PAG)

However not all of these fluids have the same level of fire performance

Take a look... Show video

REOLUBE® HYD for primary metals applications

REOLUBE® Turbofluids for power generation applications
**REOLUBE® Turbofluids**

- A range of fire resistant hydraulic fluids designed specially for the operation of EHC systems
- Enable power station operators to avoid injuries and lost business due to fires, and to achieve cost savings in maintenance, equipment and insurance
- Meet the ISO 12922 category HFDR designation for less flammable fluids and additionally meet ISO 10050 for triarylphosphate ester turbine control fluids
- Approved by numerous steam generator OEMs for their use in their equipment and must be used to maintain the equipment warranty (GE, Siemens, Alstom, Mitsubishi, Chinese National)
- Manufactured to very low acid and water content and purified to remove particulates and electrically conductive impurities
- Formulated with additives to assure oxidative stability, metals compatibility, foam and air entrainment performance
REOLUBE® Turbofluid Base Stocks

<table>
<thead>
<tr>
<th>Type</th>
<th>Raw Material Source</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xylyl</td>
<td>Natural from coal tars</td>
<td>Mixture of isomers</td>
</tr>
<tr>
<td>Tert-butyl</td>
<td>Synthetic from phenol and isobutene</td>
<td>Mixture of isomers</td>
</tr>
</tbody>
</table>
## REOLUBE® Turbofluid Grades

<table>
<thead>
<tr>
<th>ISO Viscosity at 40°C</th>
<th>Base Fluid</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trixylylphosphate (TXP)</td>
<td>REOLUBE® Turbofluid 32B GT</td>
</tr>
<tr>
<td>32</td>
<td>t-butylated triphenylphosphate (TBPP)</td>
<td>REOLUBE® Turbofluid 46B</td>
</tr>
<tr>
<td>46</td>
<td>REOLUBE® Turbofluid 46XC</td>
<td>REOLUBE® Turbofluid 46B</td>
</tr>
<tr>
<td>46</td>
<td>REOLUBE® 46RS</td>
<td></td>
</tr>
</tbody>
</table>
## Important EHC Fluid Fire Resistance Specifications

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Test</th>
<th>Typical Limit</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot manifold ignition</td>
<td>ISO 20823</td>
<td>Min 700°C ignition temp.</td>
<td>Duplicates a fluid leak dropping onto a hot surface</td>
</tr>
<tr>
<td>Wick flame persistence</td>
<td>ISO 14935</td>
<td>Max 60 sec avg. burn time</td>
<td>Tests the self extinguishing properties of the fluid</td>
</tr>
<tr>
<td>Spray ignition persistence</td>
<td>ISO 15029-1</td>
<td>Max 30 sec avg. burn time</td>
<td>Tests flammability characteristics of a high pressure fluid leak</td>
</tr>
</tbody>
</table>

ISO 20823  
ISO 14935  
ISO 15029-1
### ISO 20823 Hot Manifold Ignition Test

#### Phosphate esters are the most difficult to ignite and burn

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Ignition °C</th>
<th>Flaming Drips to Tray?</th>
<th>Flames in Tray?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphate Ester (Reolube® TF 46XC)</td>
<td>741</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Phosphate Ester (Reolube® TF 46B)</td>
<td>726</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Polyol Ester</td>
<td>495</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>PAG</td>
<td>458</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>PAO/Ester</td>
<td>474</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Mineral oil (Group I)</td>
<td>444</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- A 10 ml test portion is dropped from a set height and rate (40-60 s) onto a 700°C tube, or another temperature in series.
- The resulting spray is examined for flash or burn both on the tube and after dripping from the tube onto the tray below.
- Temperature varies along the length of the tube; ignition temperature is measured in the center (hottest area).
ISO 14935 Wick Flame Persistence Test

Self-extinguishing phosphate esters are the only fluid able to pass this test

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Pass &lt;60 s</th>
<th>Fail &gt;60 s</th>
<th>30 sec Flame Application Average Burn time, s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphate ester (Reolube® TF 46XC)</td>
<td>Pass</td>
<td></td>
<td>2.2</td>
</tr>
<tr>
<td>Phosphate ester (Reolube® TF 46B)</td>
<td>Pass</td>
<td></td>
<td>1.2</td>
</tr>
<tr>
<td>Polyol ester</td>
<td>Fail</td>
<td></td>
<td>&gt;60</td>
</tr>
<tr>
<td>PAG</td>
<td>Fail</td>
<td></td>
<td>&gt;60</td>
</tr>
<tr>
<td>PAO Ester</td>
<td>Fail</td>
<td></td>
<td>&gt;60</td>
</tr>
<tr>
<td>Mineral oil (Group I)</td>
<td>Fail</td>
<td></td>
<td>&gt;60</td>
</tr>
</tbody>
</table>

- A non-flammable aluminosilicate board is soaked in the test fluid and placed in a fluid reservoir with an exposed edge
- A flame is applied to the exposed edge and the flame persistence time is measured after removal of the igniting flame
- A total of six determinations is carried out and averaged for five different periods of flame application (2, 5, 10, 20, 30 s)
ISO 15029-1 Spray Ignition Flame Persistence Test

<table>
<thead>
<tr>
<th>Fluid</th>
<th>Pass &lt;30 s</th>
<th>Fail &gt;30 s</th>
<th>Maximum Burn Time, s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phosphate ester (Reolube® TF 46XC)</td>
<td>Pass</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Phosphate ester (Reolube® TF 46B)</td>
<td>Pass</td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Polyol ester</td>
<td>Fail</td>
<td></td>
<td>125</td>
</tr>
<tr>
<td>PAG</td>
<td>Fail</td>
<td></td>
<td>134</td>
</tr>
<tr>
<td>PAO Ester</td>
<td>Fail</td>
<td></td>
<td>124</td>
</tr>
<tr>
<td>Mineral oil (Group I)</td>
<td>Fail</td>
<td></td>
<td>130</td>
</tr>
</tbody>
</table>

- A sample of fluid is pressurized and heated to a set pressure and temperature, and then atomized through a nozzle.
- The spray produced is ignited with an oxyacetylene test flame of specified energy in succession at various points along the whole length of the spray pattern.
- After ignition, the test flame is withdrawn, and the time is measured that the flame continues to burn.
Regulatory Change is Fast Approaching

It is likely use of TXP-based fluids will be banned in the EU sometime after 2020

- Trixylylphosphates (TXP) including REOLUBE® Turbofluid 46XC have been categorized as Reprotox Hazard Category 1B, GHS code H360F (may damage fertility)
- TXP is also now on the European REACH list of candidates for Substances of Very High Concern (SVHC) and is on the draft Annex XIV
- We expect Annex XIV to be published in the immediate future with TXP included
- After inclusion in Annex XIV there are 21 months to apply for authorisation for use
- The sunset date for TXP will then be the latest application date plus 18 months
- It is very likely the use of TXP (non-authorized) will be banned in the EU sometime after 2020
LANXESS is committed to providing safer alternatives to existing products as possible.

Tert-butylphenylphosphate (TBPP) grades such as REOLUBE® Turbofluid 46B are not classified as reprotoxins and provide an excellent alternative to TXP grades.

REOLUBE® Turbofluid 46B has been used successfully in power plants for many years.

Recently, specifications for REOLUBE® Turbofluid 46B have been tightened and the product is now designed to offer comparable performance to REOLUBE® Turbofluid 46XC while eliminating safety concerns.

### Performance Comparison

<table>
<thead>
<tr>
<th>Fluid Type</th>
<th>Product Safety</th>
<th>Air Entrainment</th>
<th>Foaming Tendency</th>
<th>Water Separation</th>
<th>Volume Resistivity</th>
<th>Hydrolytic Stability</th>
<th>Oxidative Stability</th>
</tr>
</thead>
<tbody>
<tr>
<td>TXP (46XC)</td>
<td>Moderate</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
</tr>
<tr>
<td>TBPP (46B)</td>
<td>Excellent</td>
<td>Good</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good</td>
<td>Excellent</td>
</tr>
</tbody>
</table>
# REOLUBE® Turbofluid 46B and 46XC Typical Values

<table>
<thead>
<tr>
<th>Test</th>
<th>Method</th>
<th>Units</th>
<th>Reolube® Turbofluid 46B</th>
<th>Reolube® Turbofluid 46XC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air entrainment</td>
<td>ISO 9120</td>
<td>min</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Foam, tendency/stability</td>
<td>ISO 6247</td>
<td>ml</td>
<td>10/0</td>
<td>10/0</td>
</tr>
<tr>
<td>Volume resistivity</td>
<td>IEC 60247</td>
<td>Mohm/m</td>
<td>450</td>
<td>682</td>
</tr>
<tr>
<td>Acid number</td>
<td>ISO 6619</td>
<td>mgKOH/g</td>
<td>0.05</td>
<td>0.01</td>
</tr>
<tr>
<td>Water content</td>
<td>ISO 760</td>
<td>%w/w</td>
<td>0.04</td>
<td>0.03</td>
</tr>
<tr>
<td>Kinematic viscosity 40°C</td>
<td>ISO 3104</td>
<td>mm²/s</td>
<td>44.5</td>
<td>45.2</td>
</tr>
<tr>
<td>Pour point</td>
<td>ISO 3016</td>
<td>ºC</td>
<td>-24</td>
<td>-24</td>
</tr>
<tr>
<td>Water separation</td>
<td>ISO 6614</td>
<td>min</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Ox stability, acid change</td>
<td>DIN EN14832</td>
<td>mg KOH/g</td>
<td>0.05</td>
<td>0.14</td>
</tr>
</tbody>
</table>
Fluid Maintenance – Preventing Hydrolysis is Key

- Properly maintained, REOLUBE® Turbofluids can remain in good working condition for 10 years or longer
- The key maintenance goal is to prevent hydrolysis by maintaining low water and acid content
- Any hydrolysis will increase acidity, causing formation of varnish and deposit precursors
  - Water can be removed by vacuum drying
  - Acid by-products can be removed by solids treatment using ion exchange resin, Fuller’s earth or alumina
- Particulate contamination is removed by filtration
- Use of hydrolytically stable fluids in addition to proper fluid management practices is key to achieving unit maintenance and operating objectives
Hydrolytic Stability Test Method

- Use DIN 14833 test standard “Determination of the Hydrolytic Stability of Fire-resistant Phosphate Ester Fluids”
- Compare the hydrolysis performance of REOLUBE® Turbofluid 46B with an alternative tert-butylphenylphosphate (TBPP) EHC fluid available on the market
- The test severity was increased by extending the test running time from 96 hrs to 192 hours
- Test methodology
  - 300g of sample was heated with 100g of water at 85°C
  - Samples were taken at 96h, 144h and 192h
  - The TAN of the fluid and water was measured and the sum of the change in TAN of the fluid and water is reported
  - The ISO 10050 limit for this parameter after 96 hrs is 0.5 mg KOH/g
  - Two separate batches of each product were tested
REOLUBE® Turbofluid 46B Exhibits Superior Hydrolytic Stability Compared to an Alternative Fluid

Extended DIN 14833 Hydrolysis Test

- **REOLUBE TF 46B Sample 1**
- **REOLUBE TF 46B Sample 2**
- **Alternative TBPP Fluid Sample 1**
- **Alternative TBPP Fluid Sample 2**

ISO 10050 96 hour limit (0.5 mg KOH/g)

175% reduction in average TAN

Total TAN (mgKOH/g)
Summary

- The Power Generation industry requires fire-resistant fluids in steam turbine EHC systems
- Phosphate ester-based fluids provide the highest level of fire-resistance of all non-aqueous fluids
- REACH hazard classification changes will drive a move to butylated phosphate ester-based hydraulic fluids
- REOLUBE® Turbofluid 46B offers a lower toxicity solution while providing better hydrolytic stability than an alternative butylated fluid
  - This helps to extend fluid life, reduce maintenance costs, minimize unit downtime and improve operating efficiency for power stations
Booth Number 127 & 129
Contact: David Stonecipher, david.stonecipher@lanxess.com, +1 440-522-8405