Lubrication...
how’s that working for you?

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Overview

- Reliability – what does that mean for the system and the lubricant?
- Lubricants - how are they impacted and how can they help?
- Standards - how effective are they with respect to the lubricant?
Reliability

In general, reliability (systemic def.) is the ability of a system to perform and maintain its functions in routine circumstances, as well as hostile or unexpected circumstances.

*Having some level of confidence that the components will operate efficiently and trouble free for the expected life of the gearbox*

- Production is the end goal and is in part a function of reliability
- Reliability of the system is only as good as the weakest point
- Thus, reliability comes down to choices
Reliability and Choices

*Depends on many factors*

- Some we can control...
  - Choice of location
  - Choice of components
  - Maintenance schedule and monitoring

Some factors we can control through choice

- Rotor & Hub
- Transmission
  - Gears
  - Bearings
  - Seals
  - Pumps
  - Filters
  - Lubricant
- Generator
**Lubricant choices**

- Viscosity level
- Base oil type
- Additive type
- Supplements

**Consequences of our choices**

<table>
<thead>
<tr>
<th></th>
<th>High viscosity</th>
<th>Low viscosity</th>
<th>Mineral base oil</th>
<th>Synthetic base oil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Film thickness</strong></td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><strong>Wear</strong></td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td><strong>Filterability</strong></td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Low temp startup</strong></td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>
Some factors we cannot control

- Wind speed
- Transmission
- Generator load
- Seals
- Pumps
- Filters
- Dirt
- Lubricant
- Water

Operational factors - impact on the lubricant

- Speed → produces shearing in the contact zone
  - Generates heat - lowers viscosity & increases oxidation rate
  - Shear could alter viscosity (polymer containing oils)

- Torque/Load → increases contact stress
  - Generates heat - lowers viscosity & increases oxidation rate
  - Higher stress leads to reduced fatigue life for gears and bearings
Operational factors - impact on the lubricant

External contaminants

- Water
  - Increases potential for corrosion
  - Reduces fatigue life of components
- Particulate
  - Increases rate of wear (abrasive)
  - Reduces fatigue life of components, especially bearings

How do we choose an appropriate lubricant?

- Define the application requirements
- Define the fluid life expectancy
- Give consideration for “unexpected circumstances”
Helping us get there

- **Standards**
  - AGMA 6006-A03 (wind turbine standard)
  - AGMA 9005-E02 (industrial gear lubrication)
  - IEC/ISO 61400-4 (under development)
  - Equipment supplier requirements (many)

- **Experience**
  - Priceless!

 Standards for Lubricants

Mostly based on available methods

But we must ask ourselves...

*Are the methods relevant for the application?*
Relevance of methods...

- Some are...
  - Viscometrics (low and high shear)
  - Oxidation
  - Corrosion
  - Foaming

- Some are questionable...
  - Gear micropitting
  - Bearing life

Experience Highlights Some Gearbox Component Issues

- Gears
  - Although improved, gears are reported to continue experiencing micropitting

- Bearings
  - Planetary bearings are reported to have high failure rates in large turbines...size? rating? contamination?

- Contamination (water & particulate)
  - A continuing maintenance or design issue that impacts all of the above
And Some Oil Specific Issues

- Some oils (synthetics) are more expensive than others, but in some cases they do not appear to offer the end user the expected value.
  - Correct fluid for the application?

- Oil quality in service is currently monitored approximately 2x per annum using off-line analysis.
  - Relatively slow turn around time → Delays in resolving potentially damaging situations
  - Condemning limits are not always based upon experience of the application

- Adequate testing tools are not always available to the lubricant industry to develop high quality fluids required for this application

Is anything being done to address these issues? Yes.

- IEC/ISO Joint Working Group
  - Significant emphasis placed on resolving gear and bearing life issues
  - Defining impact of load on design

- An ISO committee has been formed to specifically address gear micropitting

- More effort from a number of sources to monitor oil health in real time via onboard sensors and diagnostics
IEC-ISO 61400-4 Main Elements

- Design and load specifications
- Gears
- Bearings
- Structures
- Lubrication
- Verification
- Testing

Lubrication Normative Clause (5.5)

- Describes the “shall” and “should” requirements of the lubricant
  - Type of lubricant
  - Lubricant characteristics
  - Method of lubrication
  - Oil quantity
  - Operating temperature
  - Temperature control
  - Lubricant condition monitoring
  - Lubricant cleanliness
  - Lubricant filters
  - Ports, plugs, breathers
Lubrication Annex (Informative)

- Designed to provide recommendations and guidelines
- Not a requirement to meet, just a reflection of the experience available in the industry
- Key elements
  - Fluid selection (viscosity selection)
  - Performance characteristics (recommended tests)
  - Lubricant life / condition (limits)

What about oil life?

How long will the oil last?

When does an oil need to be changed?

It depends...
### Basis for oil change

- **Fixed Time**
  - When monitoring is too infrequent or not available
  - Accessibility to the site is limited due to seasonal or location constraints
  - Duration must be based on past experience and adjusted for the site conditions

- **Condition Based**
  - When online or frequent monitoring of the oil is available and considered reliable
  - Condemning limits must be established based on experience and knowledge about oil health

### Proposed Guidelines for Limits (J WG)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Method</th>
<th>Acceptable Level</th>
<th>Cautionary Level</th>
<th>Alarm Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity (KV at 40°C)</td>
<td>ISO 3104 ASTM D445</td>
<td>Nominal VG ±5%</td>
<td>Nominal VG ±3%</td>
<td>Nominal VG ±10%</td>
</tr>
<tr>
<td>Additive Elements</td>
<td>ASTM D5185</td>
<td>New ±10%</td>
<td>New ±15%</td>
<td>New ±20%</td>
</tr>
<tr>
<td>Wear Elements</td>
<td>ASTM D5185</td>
<td>Fe &lt;50 ppm</td>
<td>Cu &lt;50 ppm</td>
<td>Fe &gt;100 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cu &lt;50 ppm</td>
<td>Al &lt;10 ppm</td>
<td>Cu &gt;75 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fe: 50-100 ppm</td>
<td>Cu: 50-75 ppm</td>
<td>Al: 10-20 ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Alarm: &gt;20 ppm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleanliness</td>
<td>ISO 4406</td>
<td>-- / 16 / 13</td>
<td>-- / 17 / 14</td>
<td>-- / 18 / 15</td>
</tr>
<tr>
<td>Water</td>
<td>ISO 12937 ASTM D6504</td>
<td>&lt;300 ppm</td>
<td>100 - 1000 ppm</td>
<td>&gt;1000 ppm</td>
</tr>
</tbody>
</table>
So, how do we provide a more reliable lubrication system...

- Better assessment of needs
  - Be able to incorporate these needs into standards in the normative “shall” section
- Better test tools for the lubricant formulator
- Anticipation of extreme conditions
- More frequent monitoring