Advanced Bearing Solutions for Wind Turbine Generators
Bearing arrangements for WTG

**Traditional arrangement**
- Locating bearing: DGBB
- Non-locating bearing: DGBB
- Typical arrangement up to 3MW
- Bearing sizes: 6326 up to 6338
- Only grease lubrication

**Arrangement for bigger powers**
- Locating bearing: DGBB+CRB
- Non-locating bearing: CRB
- Typical arrangement > 3MW
- Bearing cross sections:
  - 62.. and 60.. in C4
  - NU10.. and NU 2.. in CN or C3
- Only grease lubrication
Two different solutions from bearings point of view

INSOCOAT bearings

- Ceramic insulation layer

Hybrid bearings

- Silicon nitride (ceramic) rolling elements
INSOCCOAT bearings

High performance SKF INSOCCOAT

Ceramic insulation layer
WTG Bearings- SKF solutions

- Bearing insulation with ceramic layer material
- Fully interchangeable with existing bearings
- Available for all kinds of bearings up to 1200mm OD
- Different layer thicknesses possible
- For generator bearings IR coating with increased layer thickness P/Ns end in VL2076
- Easy and economical solution to reduce problems in existing generators

New since April 2017:
High performance SKF INSOCOAT bearings
Background of recent coating upgrade

SKF INSOCOAT bearings are well established on the market since years

- Industries: Railway, Renewable, Ind. Electrical, etc.
  - Increasing requirements on the electrical performance of the bearings in specific applications

- Worldwide presence including regions with highly humid climate
  - Therefore the requirements on insulating coatings increased in that environment

As a consequence, SKF has upgraded the INSOCOAT bearings to ensure high performance even in countries with very humid climates.
The graph shows measurement data of Ohmic resistance values from INSOCOAT bearings continuously exposed to very high humidity levels (rH > 90%, T between 20 and 30 °C) for three weeks.
# New electrical specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Breakdown voltage $[V_{DC}]$</th>
<th>Min. Ohmic resistance $[M\Omega]$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OR coating</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VL0241</td>
<td>1.000 V</td>
<td>3.000 V</td>
</tr>
<tr>
<td></td>
<td>Existing</td>
<td>Existing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50 MΩ</td>
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<tr>
<td></td>
<td></td>
<td>200 MΩ</td>
</tr>
<tr>
<td>VL0246</td>
<td>3.000 V</td>
<td>Unchanged *</td>
</tr>
<tr>
<td></td>
<td>Existing</td>
<td>New</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200 MΩ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>400 MΩ</td>
</tr>
</tbody>
</table>

| **IR coating** |                               |                                  |
| VL2071         | 1.000 V                       | 3.000 V                          |
|                | Existing                       | New                              |
|                |                               | 50 MΩ                            |
|                |                               | 200 MΩ                           |
| VL2076         | 3.000 V                       | Unchanged *                       |
|                | Existing                       | New                              |
|                |                               | 200 MΩ                            |
|                |                               | 400 MΩ                           |

Valid for: $T < 40 \, ^{\circ}C$, $rH < 60 \%$
Hybrid bearings

The solution for high demanding applications

- Bearing grade steel rings
- Silicon nitride (ceramic) rolling elements
Rolling elements made of ceramic material

Balls
For any ball bearings

Rollers
For any cylindrical roller bearings
WTG Bearings- SKF solutions

- Bearing insulation with ceramic rolling elements (Si3N4)
- Fully interchangeable with existing bearings
- Less sensitive to contamination and also in stand still periods
- At least doubled grease life and superior performance under poor lubrication

→ Improves most of the typical bearing issues in wind turbine generators (false brinelling, grease life, smearing, cage forces..)
Extended grease life of hybrid bearings

Advantages of ceramic rolling elements:

- Wettability of oil on ceramic is better than on steel
- Smaller contact ellipse due to higher stiffness of ceramic
- Better surface quality of ceramic → Less friction
- Electrically insulating

Extension of grease life by factor ≥ 2
Grease life comparison – Steel vs. Hybrid DGBBs

<table>
<thead>
<tr>
<th></th>
<th>Relative grease life performance</th>
</tr>
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<tbody>
<tr>
<td>All steel</td>
<td>0</td>
</tr>
<tr>
<td>Hybrid - Grease A</td>
<td>2</td>
</tr>
<tr>
<td>Hybrid - Grease B</td>
<td>6</td>
</tr>
<tr>
<td>Hybrid - Grease C</td>
<td>8</td>
</tr>
</tbody>
</table>
Grease life comparison – Steel vs. Hybrid CRBs

- All steel
- Hybrid - Grease A
- Hybrid - Grease B
- Hybrid - Grease C
Grease life of hybrid bearings

Conclusion of tests:

• The grease life of hybrid bearings is at least double the grease life of the equivalent all-steel bearing

• Grease life improvements up to a factor of 7 have been recognized

• Grease life and the increase with hybrid bearing is dependent on the grease selection and bearing type