PCS Instruments

LEADERS IN TRIBOLOGY TEST EQUIPMENT

Leader in Tribology Test Equipment

Wind Power Transmissions

PCS Instruments

Leaders In Tribology Test Equipment

Designing and manufacturing equipment for the testing of fuels and lubricants.

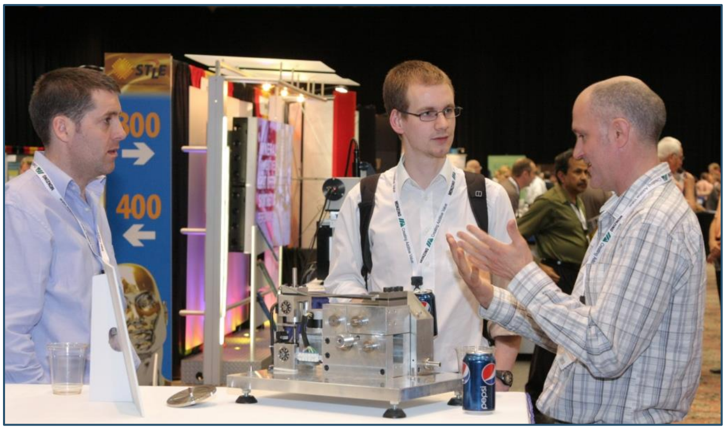
2,500 + Instruments installed

500 + Technical papers featuring equipment developed by PCS Instruments

100 + Countries using PCS Instruments equipment.

35 + Years of operation.

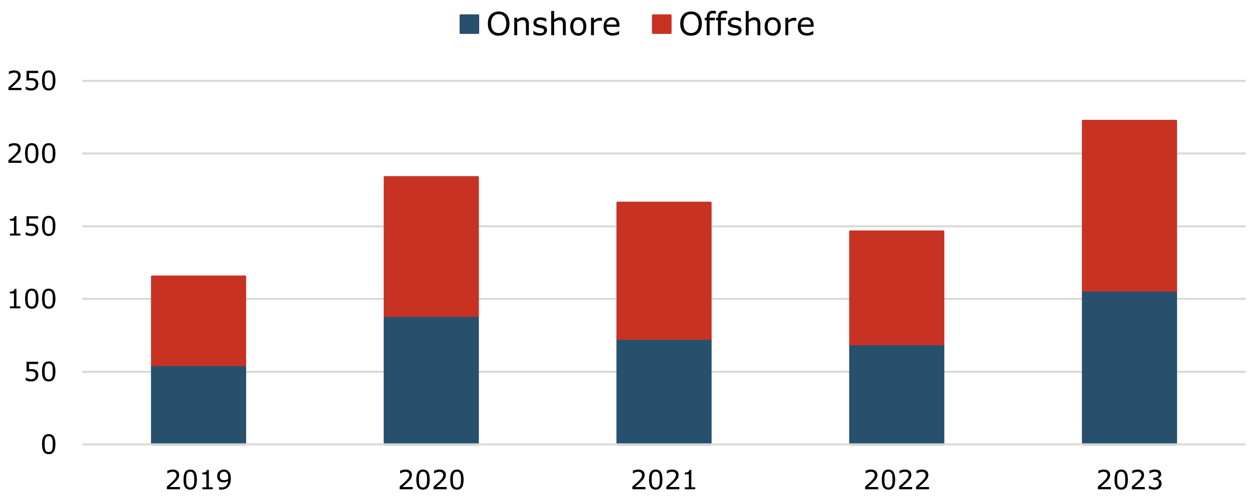
At PCS Instruments, we have been at the forefront of tribology innovation for over three decades, providing cutting-edge testing solutions for friction, wear, and lubrication across a variety of industries. As specialists in tribological research, we understand its critical role in the efficiency and durability of mechanical systems across a wide range of applications.



Global Wind Data

Insights from the Global Wind Report 2024

New Installations



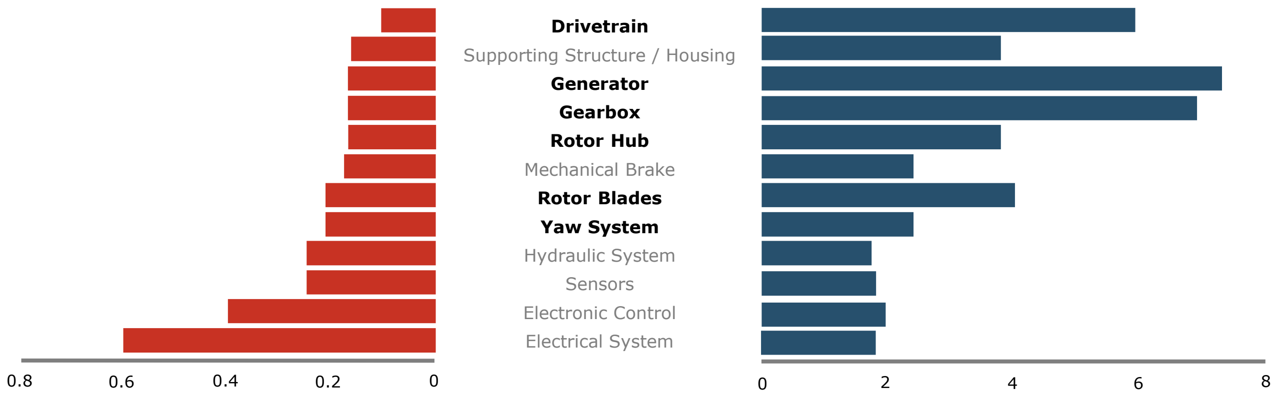
Global Wind Energy Market Expected To Grow On Average By 9% Each Year (2024 – 2028)

Technical Challenges

Obtained from 'Tribological Challenges and Advancements in Wind Turbine Bearings: A Review'

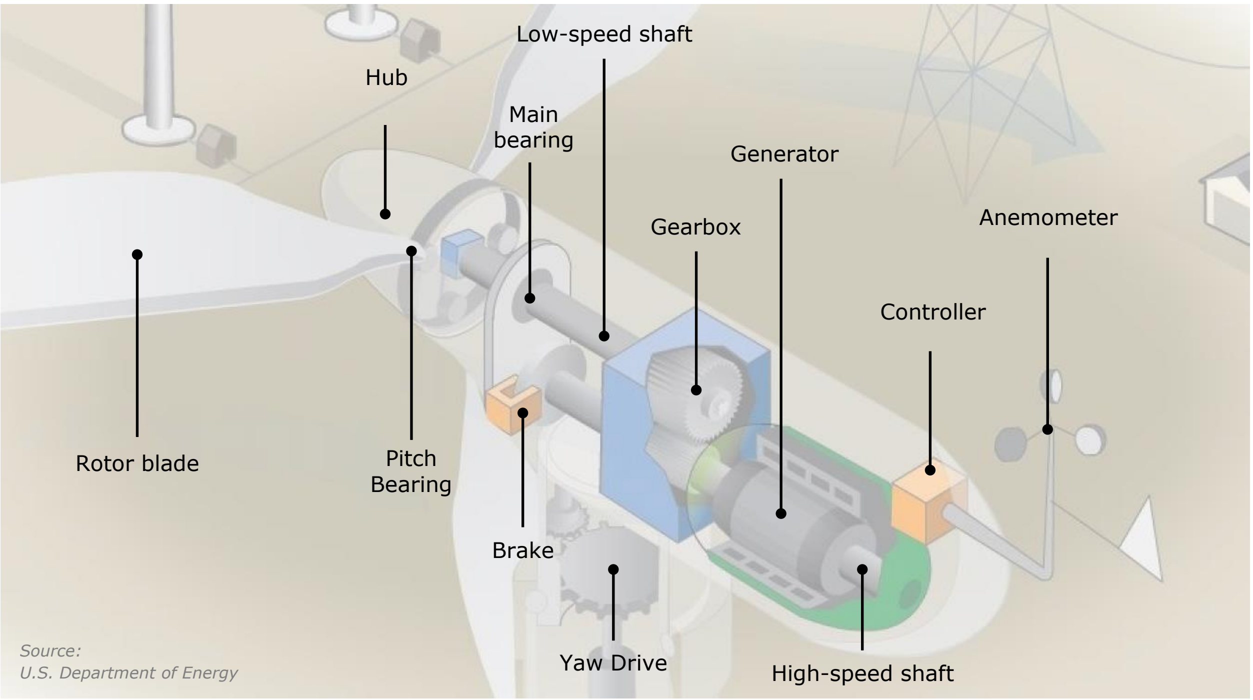
Anil Dhanola & H.C. Garg

Annual Failure Frequency **Downtime Per Failure (Days)**



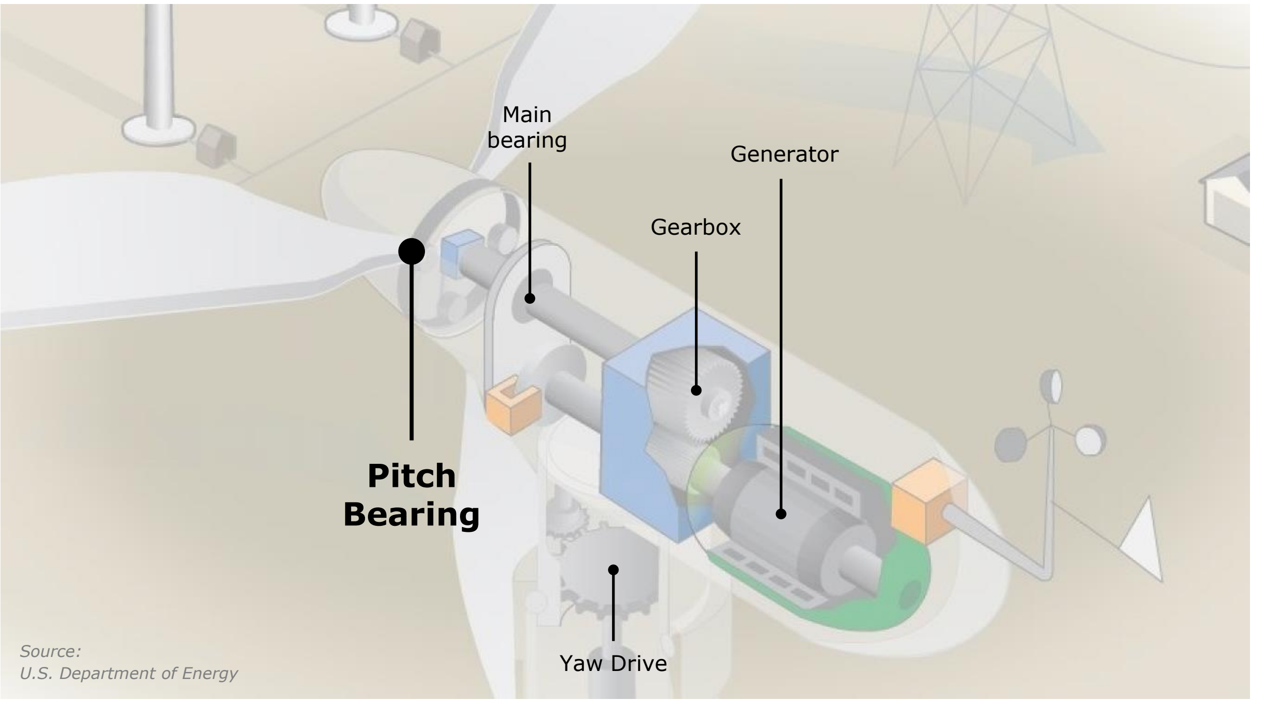
Bold = Tribological Issues

Wind Turbine Drivetrains



Component	**Function**
Rotor blade	Covert kinetic energy of the wind into rotational mechanical energy
Hub	Holds the rotor blades and connects them to the main shaft
Main bearing	Supports the weight of the hub and rotor blades while transferring torque to the gearbox
Low-speed shaft	Transmits the rotational motion of the rotor to the gearbox
Gearbox	Increases rotational speed from a low-speed rotor to a higher speed electrical generator
High-speed shaft	Transfers rotational mechanical energy from the gearbox to the generator
Generator	Coverts rotational mechanical energy into electrical energy
Controller	Responsible for starting and shutting-down the wind turbine depending on the wind conditions.
Anemometer	Measures wind speed and transmits wind speed data to the controller
Yaw drive	Keeps the rotor facing into the wind as the wind direction changes
Brake	Controls overspeed, and provides parking and emergency braking

Primary Bearing Systems



Pitch Bearings

Type

Slewing bearings, typically double-rowed, 4-point contact ball bearings

Characteristics

- High loads
- Small reciprocating movements induced by the pitch system or vibrations from the wind.

Resultant Wear / Damage

- False Brinelling
- Fretting Corrosion

Lubricant Type

- Grease

Relevant PCS Instruments

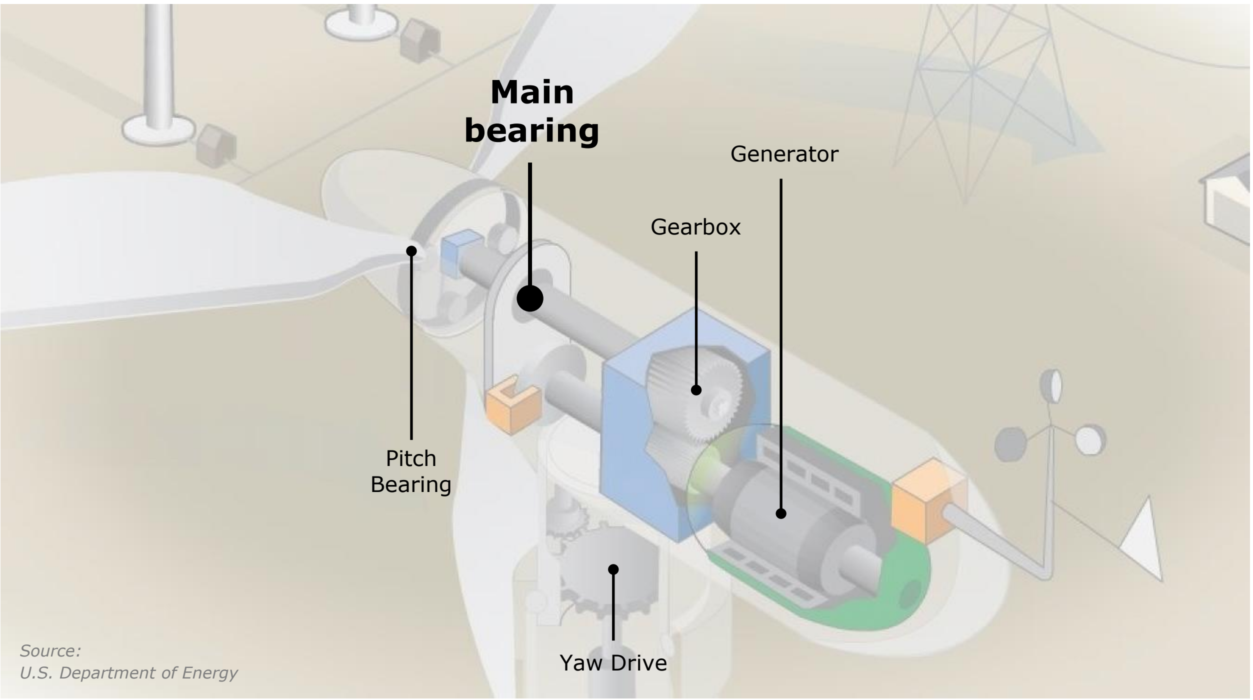
- HFRR
- MPR+GI

Relevant Literature

Effect of Lubricant Properties and Contact Conditions on False Brinelling Damage

Rachel Januszewski, Victor Brizmer & Amir Kadiric

Primary Bearing Systems



Main Bearings

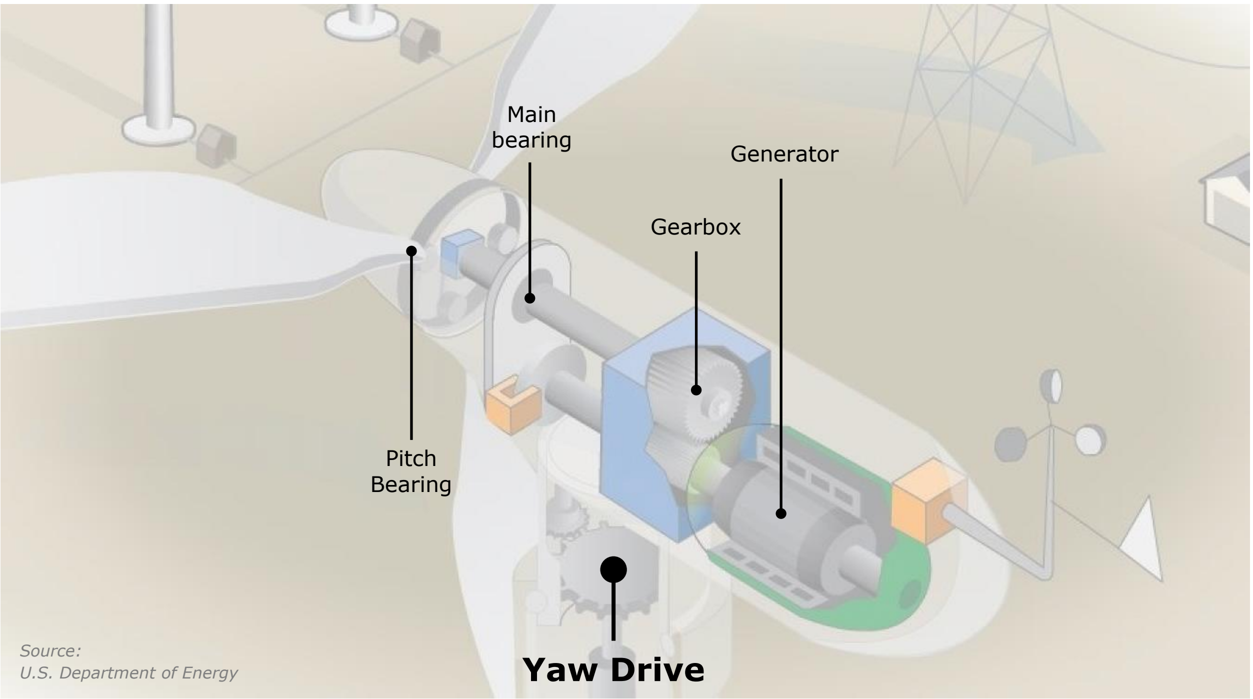
Type	Characteristics	
Spherical / Tapered roller bearings. Interested in transitioning to pad bearings.	• Large component (~ 2m bore) • Low speeds (~10rpm) • Continually variable loads, including high thrust loads from the wind.	
Resultant Wear / Damage	**Lubricant Type**	**Relevant PCS Instruments**
• Abrasive wear • Scuffing / smearing • Micro-pitting • Spalling	• Grease	• MPR+GI • ETM

Relevant literature

Influence of Dumbbell Base Oil on Micropitting

Mao Ueda, Janet Wong & Hugh Spikes

Primary Bearing Systems



Yaw Bearings

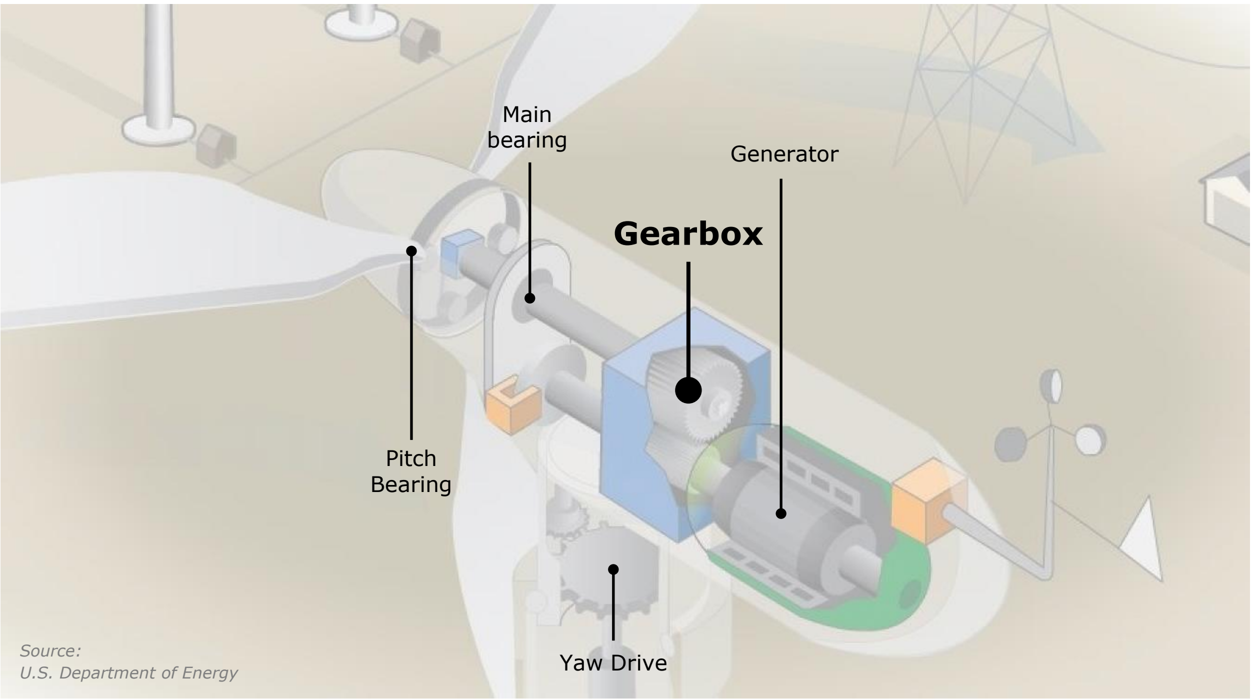
Type	Characteristics	
Slewing bearings, typically 4-point contact ball, 8-point contact ball or crossed cylinder roller bearings	• High static and dynamic loads • Corrosive environment • Difficult to maintain or replace	
Resultant Wear / Damage	**Lubricant Type**	**Relevant PCS Instruments**
• Fatigue • Scuffing	• Grease	• MPR+GI • ETM

Relevant Literature

In-Situ Observation of the Effect of the Tribofilm Growth on Scuffing in Rolling-Sliding Contact

Mao Ueda, Hugh Spikes & Amir Kadiric

Primary Bearing Systems



Gearbox Bearings

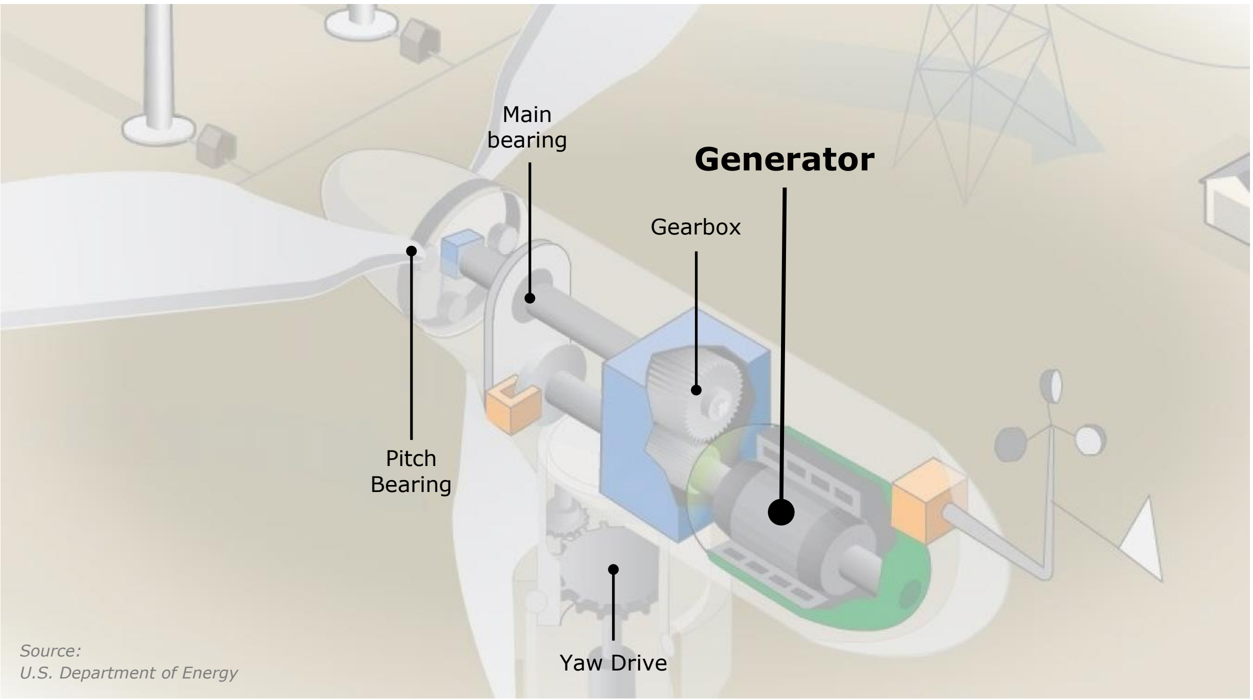
Type	Characteristics	
Roller bearings (spherical, cylindrical and tapered)	• Rapid acceleration and deceleration events • Fluctuating temperatures • Vibrations	
Resultant Wear / damage	**Lubricant Type**	**Relevant PCS Instruments**
• WECs, leading to axial cracking	• Gear Oil	• MPR • ETM + SLIM

Relevant Literature

Investigation of Bearing Axial Cracking: Benchtop and Full-Scale Test Results

Jonathan Keller, Benjamin Gould & Aaron Greco

Primary Bearing Systems



Generator Bearings

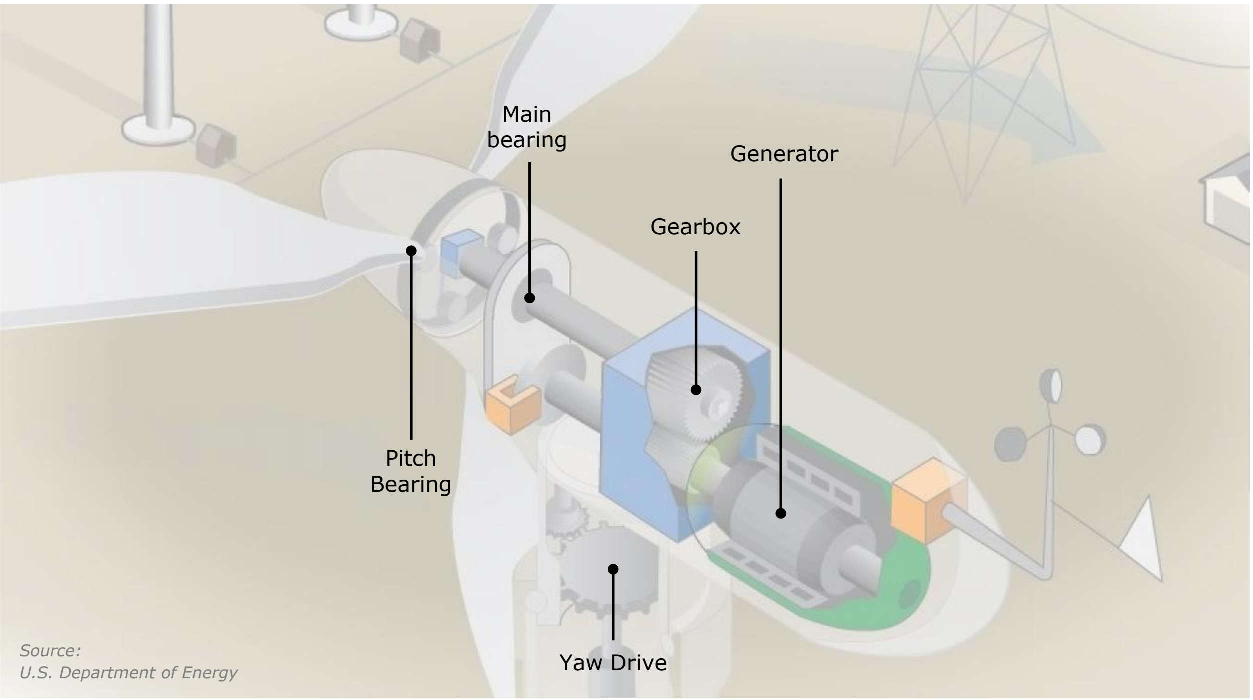
Type	Characteristics	
Ball bearings	• Stray currents	
Resultant Wear / Damage	**Lubricant Type**	**Relevant PCS Instruments**
• Grey frosting • Fluting • WECs • Pitting	• Grease	• MTM-EC

Relevant Literature

Influence of Electric Potentials on Surface Damage in Rolling–Sliding Contacts Under Mixed Lubrication

Ammad Yousef, Hugh Spikes, Liang Guo & Amir Kadiric

Primary Bearing Systems



In Summary

			Transmission Bearings			Adjustment Bearings	
			Main	Gearbox	Generator	Pitch	Yaw
Material failure	Cracks & fracture	Forced fracture	X	X	X	X	X
		Fatigue fracture	X	X	X	X	X
		Thermal cracking	X	X	X		
	Wear	Adhesive wear	X	X	X		
		Abrasive wear	X	X	X		
		Corrosion				X	X
		Brinelling				X	X
Premature fatigue	Plastic deformation	Excessive load	X	X	X	X	X
		Loose fits	X	X	X	X	X
		Misalignment	x	X	x		
	Electric arc erosion	Excessive voltage	X		X		
		Current leakage			X		
	Mounting failure	Overheating		X	X	X	X
		Inadequate bearing					
	Lubricant	Lubricant failure		X	X	X	X
		Contamination		X	X	X	X

A review of failure modes, condition monitoring and fault diagnosis methods for large-scale wind turbine bearings

Zepeng Liu, Long Zhang

Relevant Instruments / Accessories

MPR

Features:

- Capable of achieving over 1 million contact cycles per hour.
- Independently driven motors enable any slide-to-roll ratio and a wide range of speeds.
- Requires only a small sample volume (~150ml).
- Continuously measures friction and acceleration during testing
- The only instrument specified in the 'SAE International MPR Micropitting Test Method ARP6991' standard for evaluating the micropitting performance of aviation turbine oil formulations.
- Grease testing is possible with the dedicated PCS Grease Injector system.

Key Technical Specifications:

Load	100 to 1250 N
Contact pressure	0.86 – 4.7 GPa
Entrainment speed	Up to 4 m/s
Slide-to-roll ratio	0 to +/- 200 % (+ Contra-rotation)
Temperature range	Ambient to 135 °C
Maximum roller torque	20 Nm (Total of all 3 contacts)

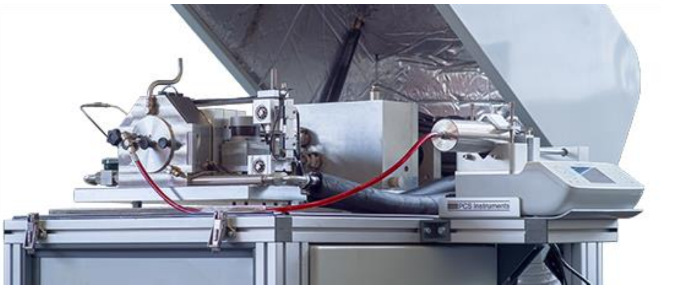
MPR + GI

The MPR GI delivers grease to the contact in a controlled, accurate and repeatable way, preventing starvation and allowing for the clear assessment of fatigue behaviour of greases.

Max. Syringe Volume
300ml

Rate of Injection
0.07 to +20,000 ml/Hr
(grease consistency-dependant)

Max. NLGI Grade
3



Relevant Instruments / Accessories

ETM

Features:

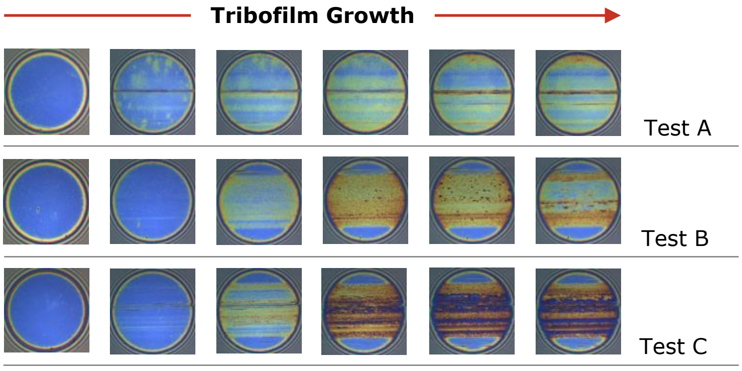
- Ball on disc benchtop tribometer for measuring the frictional properties of lubricated and unlubricated contacts under extreme contact pressures
- Independently driven ball and disc motors allows a range of slide roll ratios at loads up to 1650 N
- Optional SLIM system allows the study of tribofilm formation under extreme conditions.

Key Technical Specifications:

Load	100 to 1650 N
Contact pressure	Up to 3.5 GPa with AISI 52100 Steel specimens Up to 7.1 GPa with Tungsten Carbide specimens
Entrainment speed	Up to 3.5 m/s
Slide-to-roll ratio	0 to +/- 200 % (+ Contra-rotation)
Temperature range	Ambient to 150 °C
Test sample volume	30ml (10ml with optional pot filler)

ETM + SLIM

The Space Layer Imaging Method (SLIM) enables users to characterise the activity of tribofilm forming additives within different lubricant packages – E.g. extreme pressure and antiwear additives.



The details given in these images are used by chemists and oil formulators to develop new oils

Relevant Instruments / Accessories

HFRR

Features:

- A ball-on-plate reciprocating friction and wear test system, for assessing the performance of both fuels and lubricants under boundary conditions.
- Widely used to study fretting wear phenomena.
- Actively controlled environmental chamber allows for precise control of temperature and humidity

MTM + EC

Features:

- Enables novel investigations into the effects of electric potentials on tribological contacts.
- Both AC and DC voltages can be applied.
- Ball and disc specimens are electrically isolated, allowing either specimen to act as the anode or cathode.
- User-provided oscilloscopes and power supply units allow for extensive customisation.
- High sampling rates of up to 80M samples per second are possible, enabling individual discharge events to be identified.
- Full control and automation possible through the MTM-EC software.

MTM-EC

EC potentials have been shown to effect:

- Friction
- Wear
- Lubricant additive performance

Key EC Technical Specifications:

AC		**Low Range**	**High Range**
	Voltage (Pk/Pk)	0 to 20V	0 to 30V
	Current (Pk/Pk)	0 to 400mA	0 to 580mA
DC		**Low Range**	**High Range**
	Voltage	0 to 10V	0 to 35V
	Current	0 to 200mA	0 to 2A

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