



NREL Reliability Data Collection Experiences

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U.S. Wind Data Collection Coordination and Standardization Meeting

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Background

- Drivetrain Reliability Collaborative (formerly Gearbox Reliability Collaborative)
 - Aims to improve gearbox reliability and availability
 - Takes a multifaceted approach: testing, modeling, condition monitoring, and database.
- Gearbox Reliability Database
 - Aims to quantify the magnitude of gearbox problem and identify top failure modes and root causes
 - Collects gearbox failure event data from project partners; all have executed nondisclosure agreements with the National Renewable Energy Laboratory (NREL).
 - Directs wind turbine gearbox reliability research and development (R&D) and provides a benchmark for evaluating technology advancements.

Stand-Alone Software

- GearFacts: a gearbox rebuild event data recording tool
 - Structured data collection
 - Embedded visual illustration of gearbox models
 - High-resolution damage photos
 - Integrated gear and bearing failure atlases
 - Interactively support preliminary failure mode classifications
 - Generation of reports



- Data transmission.
 - One event file size: ~ 1 gigabyte
 - SharePoint site
 - Mail of portable storage media.

Template in Excel

- Data fields collected by GearFacts were prioritized into three categories: high, medium, and low.
- Microsoft Excel spreadsheet template is used for data collection with only high-priority fields.
- Template is convenient for data sharing by partners.

Wind Site Name
Wind Site State Province Region
Wind Site Country
WTG Make/Model
WTG Pad No.
WTG Total Run Hours Estimation
WTG Total Production kWh Estimation
WTG Type of Power Conversion
WTG Type of Generator
Gearbox Maker/Model (if you are not comfortable sharing this with NREL, please skip)
Gearbox Serial No. (if you are not comfortable with the full description of the serial No., please share the last three digits.)
Gearbox Originally New or Rebuilt
Install Date
Failure Date
Gearbox Run Hours Estimation
Gearbox Production Estimation (kWh)
Original Lubricant Type
Current Lubricant Type
Inline Filter Rating (50 mrons, 20 microns, 10 microns, or 5 microns)
Offline Filter Rating (3 microns)
How was Damage Detected
Dominant Failure (Worst) Location
Secondary Failure (2nd Worst) Location
Dominant Failure (Worst) Mode
Secondary Failure (2nd Worst) Mode
Corrective Actions (Uptower repair, internal component replacement, or gearbox replacement)
Other Drivetrain Component Failures Before this damage
Other Drivetrain Component Failures After this damage
Additional Notes

Tablet-Deployable Tool

- Synchronize with a central server.
- Interface with popular asset management platforms.

NREL Wind O&M Database Major Component Failure Report Component Failed NREL Record ID

Incident General | Wind Site | Turbine General | Failed Component | Failure Photos

NREL Data Partner Report Number

Report Date & Time

Equipment Owner

Equipment Owner Phone

Report Contact

Report Contact Phone

Out of Service Date

Return to Service Date

Service Company Name

Work Done By

Work Done On

Total Service Cost

General Service Cost Breakdown Percentage (enter as decimal)

Labor

Parts

Logistics

Rigging

COLOR KEY

- High Priority
- Medium Priority
- Lower Priority

Tablet-Deployable Tool (Cont.)

Multiple tabs for major components

NREL Wind O&M Database Major Component Failure Report Component Failed NREL Record ID

Incident General | Wind Site | Turbine General | **Failed Component** | Failure Photos

Failure General | **Gearbox** | Main Bearing

Gearbox Make	<input type="text"/>	Similar Gearbox Failures at this Site?	<input type="text"/>	Last Oil Change Date	<input type="text"/>
Gearbox Model	<input type="text"/>	In General, How Many Similar	<input type="text"/>	Oil Time	<input type="text"/>
Gearbox Serial No.	<input type="text"/>	Dominant Failure Mode	<input type="text"/>	Lubricant Manufacturer	<input type="text"/>
Gear Ratio	<input type="text"/>	Dominant Failure Location	<input type="text"/>	Lubricant Type and Grade	<input type="text"/>
Gearbox New or Rebuilt?	<input type="text"/>	(if bearing)		Volume of Lubricant (liters)	<input type="text"/>
Gearbox Mounting	<input type="text"/>	Dominant Failure Bearing Type	<input type="text"/>	Minimum Online Filter Beta Ratio	<input type="text"/>
Gearbox Run Hours	<input type="text"/>	Secondary Failure Mode	<input type="text"/>	Minimum Offline Filter Beta Ratio	<input type="text"/>
Gearbox Production (kWh)	<input type="text"/>	Secondary Failure Location	<input type="text"/>	Has Desiccant Breather?	<input type="text"/>
Planet Carrier Bearing Types	<input type="text"/>	(if bearing)		Oil Heater Type	<input type="text"/>
Planet Bearing Types	<input type="text"/>	Secondary Failure Bearing Type	<input type="text"/>	Oil Sample Analysis Available?	<input type="text"/>
Gearbox Comments	<input type="text"/>			Gearbox Oil Water Content (ppm)	<input type="text"/>
Gearbox Schematic Container	<input type="text"/>			Sample Collection Point	<input type="text"/>
Gearbox Kinematic Container	<input type="text"/>			Sample Collection Date	<input type="text"/>
				Lubricant Comments	<input type="text"/>
				If gearbox was removed from turbine, how was it stored after it was removed?	<input type="text"/>

Web Interface

- A centralized location that provides objective and interactive benchmarking of gearbox reliability
- Terminology based on International Electrotechnical Commission, International Standards Organization, and American Gear Manufacturers Association standards
- Updated interactive statistics narrowing down to bearings or gears
- Handy tools for plot capturing, sharing, and reporting
- **All data accessed by partners through the web interface are:**
 - Protected by nondisclosure agreements and can only be used for internal references
 - Cannot be shared with the general public.

Web Interface (Cont.)

Interactive statistics: own vs. global data



Web Interface (Cont.)

- Data validation and record editing
- Source nonidentifiable global data downloads.

The screenshot displays the 'Gearbox Reliability Database' web interface. On the left, a table lists gearbox records with columns for 'Edit', 'ID', and 'G'. A modal form is open for editing record ID 4208, showing fields for Gearbox ID (2444-21), Failure Date (08/09/2011), RTS Date (11/28/2011), Component (Bearing), Failure Mode (Select a Failure Mode), Failure Location (Select a Failure Location), Gearbox Manufacturer (Select a Gearbox Manufacturer), Turbine Manufacturer (Select a Turbine Manufacturer), and Root Cause. The form includes 'Cancel' and 'Save' buttons. On the right, a table displays a list of incidents with columns for 'Failure Date', 'RTS Date', 'Component', 'Failure Mode', and 'Failure Location'. The table contains 10 rows of data.

Failure Date	RTS Date	Component	Failure Mode	Failure Location
04/20/2013	05/10/2013	Gear		
03/12/2011	03/26/2011	Bearing		
08/14/2012	10/19/2012	Bearing		
08/14/2012	10/25/2012	Bearing		
04/12/2013	05/02/2013	Bearing		
05/02/2012	06/02/2012	Bearing		
08/09/2011	11/28/2011	Bearing		
07/01/2010	08/05/2010	Bearing		
12/23/2013	01/24/2013	Bearing		

U.S. Department of Energy/NREL Unique Role

- Credible third party
- Actively supporting international standards or best practices development
- Diverse and capable resources:
 - Subject matter experts
 - Data scientists
 - High-performance computing
 - Mass storage.

Acknowledgements

- U.S. Department of Energy Wind Program
- Data-sharing partners
- The gearbox reliability database project team
 - NREL technology transfer office
 - Data collection tools developers
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Thank you!

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