

Leeward Renewable Energy

Blade Health Management

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Blade Health Monitoring

External/Drone Inspection



Common ~ 100% of Fleet

Internal Inspection



Less Common ~ 10% of Fleet

Data Monitoring / Alarms

Turbine	Gearbox	GBX Rating
F01	Possible root wear on the LS pinion	2
F07	No issues observed, light wear	2
F20	Moderate Debris denting on RS LS BRG, Moderate abrasion wear with micro and macro pitting on planet #2	3
F22	Mild Wear	2
F24	Heavy abrasion wear and spalling on planet bearing #2	4
F27	Mild wear	2
F29	Mild wear	2
F36	Mild wear	2
F42	Heavy abrasion wear and spalling on planet bearing #2	4
F43	Mild wear	2
G009	Fractured low speed pinion tooth. This can be repaired uptower.	4
G010	Debris denting with stress concentrations on ring gear.	2
G14	Possible root wear on the LS pinion, fracture developing on IMS pinion. Need further evaluation.	3

Rare ~ 5% of Fleet

unless we count power curve monitoring!

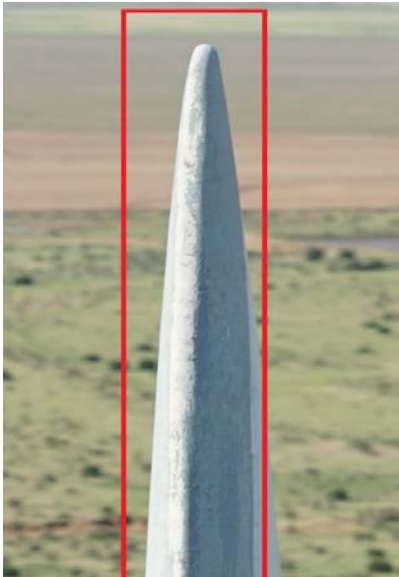
- Establish Condition of Blade from Monitoring Mode
- Evaluate Defect
 - Likelihood and speed of propagation
 - Risk of defect propagation to complete failure
 - Compare to similar defect history
- Categorize Defect / Determine Operation Impact
 - Shutdown
 - Derate
 - Operate & Monitor

Component Damage Ratings

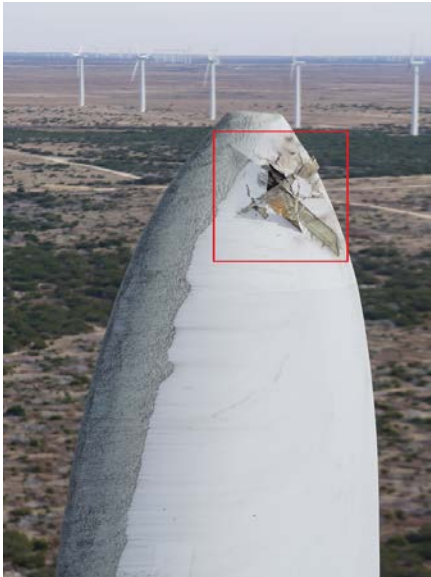
Damage Category	Observations	Stage of Damage	Planned Action
CAT1	No observable damage	N/A	No Action Required
CAT2	Minor signs of damage	No obvious failure developing	No Action Required
CAT3	Moderate signs of damage	Failure developing	Plan Follow up Inspection
CAT4	Advanced signs of damage	Failure imminent	Schedule Repair or Replacement
CAT5	Failed Component	Component won't operate as intended or risk of catastrophic failure imminent	Remove equipment from service and schedule replacement

Leeward Damage Categories Reflect Planned ACTION

Common Examples



Leading Edge Wear



Lightning Damage



Lightning Damage

- Possible when...
 - Defect not affected by edgewise loading
 - *Why? Rotational gravity loads don't change much with derating*
 - Load reduction mitigates risk of defect propagation
 - *Will derate reduce risk of further cracking/tearing/etc.?*
 - *Clear technical justification*

Point of View: Derating not a commonly used damage mitigation tool

- Basic strategy to mitigate risk is to monitor blade health

- Monitoring modes are risk based
 - All blades are subject to external visual type inspection
 - Internal and data monitoring set up for specific defect monitoring

- Damage ratings focus on next action to take (operations focused)

- Operational – Planning & Scheduling of repairs
- Financial/Business – Adjusting expectations for repair budgets, substantiating repair budgets.
- Technical – actual risks of doing nothing compared to doing something. Especially true of LE related production losses