GE
Measurement & Control

Wind Turbine Health Indicators

Dynamic Energy Index (DEI)

Wind turbine gearboxes have a large number of components and can produce a rich mixture of operating and fault frequencies. These gearboxes typically have several increasing stages: one or more planetary stages followed by one or two conventional stages. Each stage has a characteristic set of mesh frequencies and harmonics that is different from what is produced in other stages. Each shaft in the gearbox has two or three rolling element bearings, each capable of producing its own set of fault frequencies. Finally, impacting events (due to rolling element bearing faults or broken gear teeth) can excite gearbox casing structural resonances. These structural frequencies tend to be well above those produced by bearing faults or meshes, typically 4–10 kHz or higher.

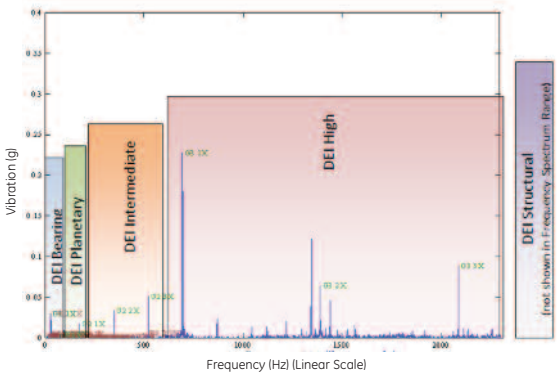
The Dynamic Energy Index (DEI) was developed to provide a relatively simple set of five numbers that characterize the vibration energy in spectral bands that roughly correspond to bearing fault frequencies, mesh frequencies in the different stages, and structural frequencies (Table 1). Because of the variable speed nature of wind turbines, the lower four DEI band boundaries are adjusted with turbine speed. The gearbox structure does not change with speed, so the highest DEI band boundaries are not adjusted for speed.

DEI Variable	Full Speed Frequency Range	Description
DEI Bearing	0-25 Hz	Bearing fault frequencies
DEI Planetary	28-130 Hz	Planetary stage mesh frequencies
DEI Intermediate	145-570 Hz	Intermediate stage mesh frequencies
DEI High	590-3300 Hz	High-speed stage mesh frequencies
DEI Structural	4-10 kHz	Gearbox structural frequencies

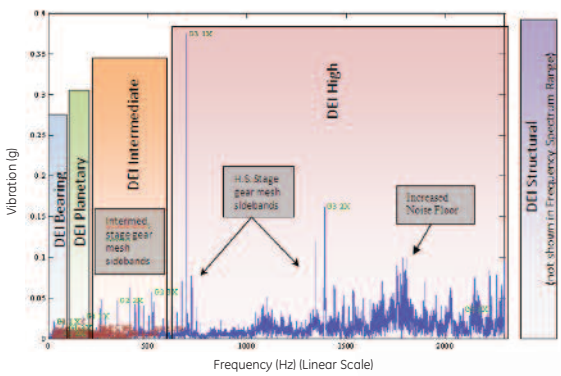
Table 1. DEI bands and descriptions. The first four band boundaries are adjusted for turbine speed.

In gearboxes, bearing and mesh loads are a function of the torque being delivered through the gearbox. High torque can produce high loads, which in turn will produce higher vibration levels. To compensate for this affect, the DEI spectral energy calculations in ADAPT Wind are divided by torque to help reduce the influence of torque on the DEI values.

Healthy Gearbox



Damaged Gearbox



Finally, a DEI multiplier is used to produce a number that is easier to use. DEI values have no physical meaning in and of themselves; they are used to trend vibration levels over time. To summarize, DEI is calculated through a number of steps. For each DEI band;

- Sum the squares of the individual bin amplitudes
- Multiply by a factor to produce a more useful number
- Divide the sum by the generator torque

Each DEI band value can be independently alarmed and trended, and alarms can be set independently for different wind turbine power bands (modes). In ADAPT Wind, it is possible to set a total of 25 DEI alarms, five for each power mode times five DEI bands.

Because DEI is intended as a gearbox monitoring tool, ADAPT Wind provides DEI values only for the three gearbox channels, planetary, intermediate, and high-speed.

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