AN22E

Application Note
Vibration Measurement at Wind Energy Plants
VDI 3834 Part 1

Scope of VDI 3834 Part 1

VDI 3834 Part 1 gives practical advice on the measurement and evaluation of the mechanical vibrations of wind energy plants. It is applicable for generators with gearbox between 100 kW and 3 MW in onshore locations.
VDI 3834 Part 1 does not deal with torsional vibration of the power train and with the condition of roller bearings and cogwheels.
The reference values given in this guideline are not intended for predictive maintenance.

Measurement Method

Wind energy plants are exposed to changeable wind speeds and wind directions. resulting in variable vibrations with high magnitude changes. The known methods of machine condition monitoring, for example to ISO 10816, are only applicable with restrictions.
For wind energy plants averaging of the measured vibration values over a defined period is necessary. The energy equivalent mean value, also called interval RMS, is calculated. It indicates the total vibration stress during the measuring period T_0.

$$a_{W0} = \sqrt{\frac{1}{T_0}\int_0^{T_0} a_w^2(t)dt} \qquad \text{Equation 1}$$

with:

$a_W(t)$ vibration quantity (acceleration or velocity) as function of time t

T_0 measuring period

For the aerodynamically induced vibrations of tower and nacelle with main frequencies between 0.1 and 10 Hz and relatively high magnitudes a measuring period of 10 minutes is recommended. This ensures exact measurement of frequencies below 1 Hz.
In the case of different operation conditions it can be necessary to divide the total measuring period of 10 minutes into several sections. The total vibration value is then calculated as follows:

$$a_{W0} = \sqrt{\frac{1}{T_0}\sum_{e=1}^{n} a_{we}^2 \cdot T_e} \qquad \text{Equation 2}$$

with

$$T_0 = \sum_{e=1}^{n} T_e$$

At gearbox and generator characteristic vibrations between 10 and 1000 Hz may occur. Here a measuring period of 1 minute is sufficient.
The following table shows the characteristics to be measured for the different components:

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Component	Characteristics	Measuring period	Measuring location	Direction
Nacelle and Tower	Acceleration ≤ 0.1 to 10 Hz Velocity ≤ 0.1 bis 10 Hz	10 minutes	• In the nacelle on both sides of the rotor bearing base and on both sides of the main frame near the generator • At the tower below the azimuth bearing	Axial, horizontal und vertical direction of rotor shaft
Rotor bearing with rolling elements[1]	Acceleration ≤ 0.1 to 10 Hz Velocity 10 to 1000 Hz	10 minutes 1 minute	• In designs with two separate rotor bearings on both bearing cases • In three-point bearing designs at the case of the front bearing	Axial, horizontal und vertical direction of rotor shaft
Gearbox	Acceleration ≤ 0.1 to 10 Hz Acceleration 10 to 2000 Hz Velocity 10 to 1000 Hz	10 minutes 1 minute 1 minute	• In designs with separately mounted gearbox and gearboxes with integral rotor bearing at the gearbox case near the rotor or main bearing	Axial, horizontal und vertical direction of rotor shaft
Generator	Acceleration 10 to 5000 Hz Velocity 10 to 1000 Hz	1 Minute 1 Minute	• In designs with integrated gearbox and generator at the case near the input and outer bearings • In designs with flexibly coupled generators at the case of both bearings	Axial, horizontal und vertical direction of rotor shaft

1 For journal bearings vibration displacement is to be measured by means of proximity probes. This measurement cannot be performed with the VM30-W.

Operating Conditions for Measurement

The criteria given below are applicable under normal operating conditions, i.e. stable operation with at least 20 % nominal power. The reference values are valid for the entire power range of the wind energy plant. It can be useful, however, to take measurements at certain conditions where increased vibration occurs.

Evaluation Criteria and Reference Values

VDI 3834 Part 1 evaluates the vibration by two criteria which have been derived on the basis of a sufficient number of measurements at different types of existing wind energy plants.
The first criterion is the machine component, like tower, nacelle, gearbox or generator. Each component can be divided into different designs.

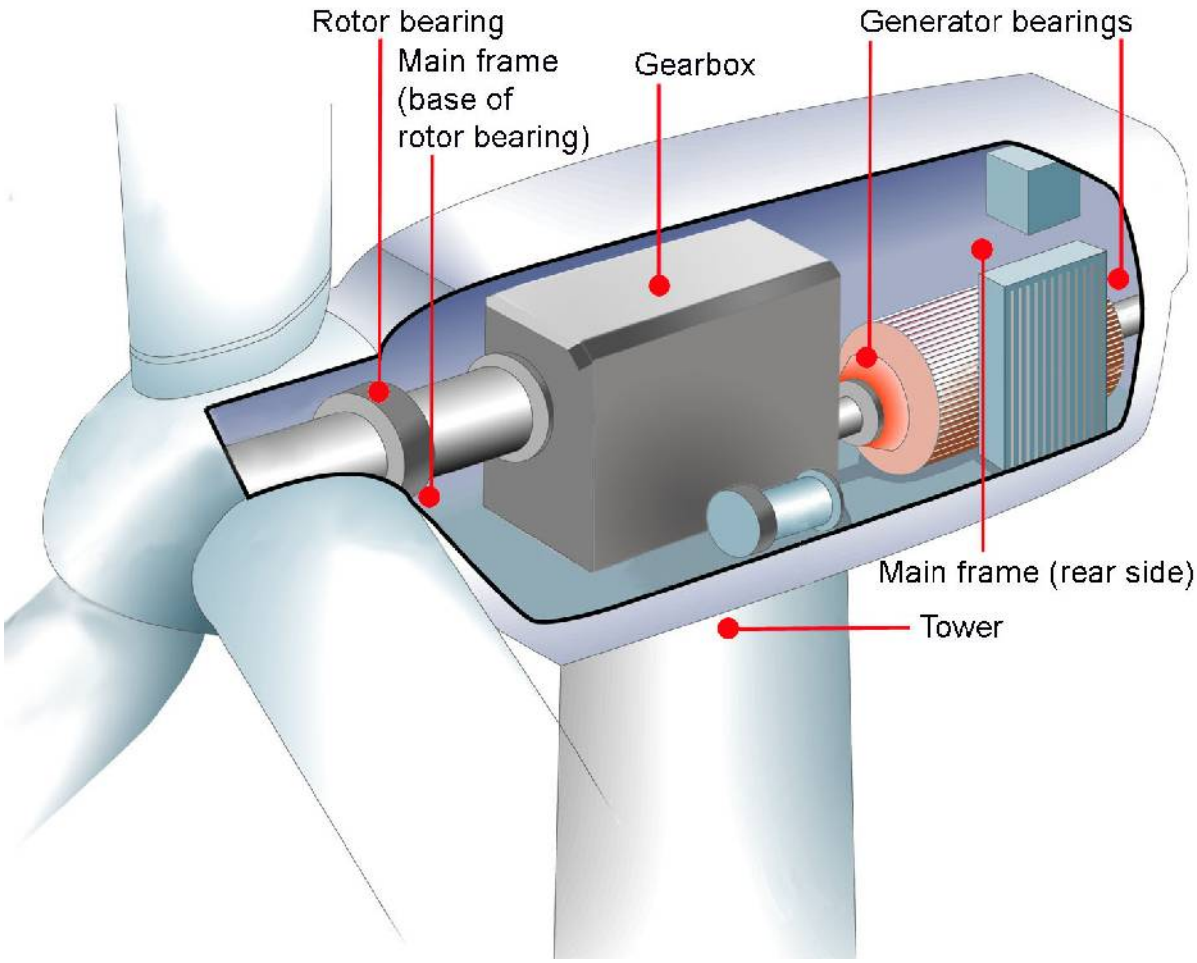

Figure 1: Components and measuring points to VDI 3834 part 1

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The second criterion are the values of the characteristics measured at these components. The measured values are classified into three zones. This allows a qualitative evaluation and gives information about possible risks.
The evaluation is performed on the basis of acceleration and velocity measurements at different locations. The worst zone value is the relevant one.

Zone 1: Good for continuous operation.
Zone 2: Possibly not good for continuous operation. An examination of the source of vibration is recommended.
Zone 3: Danger of damage.

The following table shows statistically-derived reference values of acceleration and velocity for different components.

Component	**Acceleration**		**Velocity**	
Nacelle and Tower	Frequency range ≤ 0.1 to 10 Hz		Frequency range ≤ 0.1 to 10 Hz	
	Zone limit I/II	Zone limit II/III	Zone limit I/II	Zone limit II/III
	0.3 m/s²	0.5 m/s²	60 mm/s	100 mm/s
Generator	Frequency range ≤ 0.1 to 10 Hz		Frequency range 10 to 1000 Hz	
	Zone limit I/II	Zone limit II/III	Zone limit I/II	Zone limit II/III
	0.3 m/s²	0.5 m/s²	2.0 mm/s	3.2 mm/s
Gearbox	Frequency range ≤ 0.1 to 10 Hz		Frequency range 10 to 1000 Hz	
	Zone limit I/II	Zone limit II/III	Zone limit I/II	Zone limit II/III
	0.3 m/s²	0.5 m/s²	3.5 mm/s	5.6 mm/s
	Frequency range ≤ 10 to 2000 Hz			
	7.5 m/s²	12.0 m/s²		
Generator	Frequency range ≤ 10 to 5000 Hz		Frequency range 10 to 1000 Hz	
	Zone limit I/II	Zone limit II/III	Zone limit I/II	Zone limit II/III
	10 m/s²	16 m/s²	6.0 mm/s	10 mm/s

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