GE Energy

Commercial Documentation
Wind Turbine Generator Systems
2.5-103 - 60 Hz

Product Acoustic Specifications

Canada Specific
Normal Operation according to IEC 61400-11

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1 Introduction

This document defines the noise emission characteristics of the wind turbine series 2.5-103, 60 Hz version, equipped with 103 m rotor diameter (GE 50.2 type blade) operating in normal operation (NO).

General Electric continuously verifies specifications with measurements, including those performed by independent institutes.

The calculated apparent sound power level $L_{WA,k}$ as function of v_{10m} (reference wind speed 10 m above ground level) is provided for **normal operation** (NO) over cut-in to cut-out wind speed range.

The corresponding wind speeds at hub height v_{HH} are provided assuming different standard hub heights and a logarithmic wind profile.

If a wind turbine noise performance test is to be carried out, it needs to be done in accordance with both IEC 61400-11 and GE's "Machine noise performance test" reference guidelines.

Paragraph §2 provides **nominal calculated acoustic performance** for:

- 2.5-103 (60 Hz) calculated apparent sound power level $L_{WA,k}$ as function of v_{10m} and at **95% rated electrical power** per IEC 61400-11.
- 2.5-103 (60 Hz) tonality level $\Delta L_{a,k}$ per IEC 61400-11

Paragraph §3 provides 2.5-103 acoustic performances additional data:

- The wind speeds at reference height v_{10m} extrapolated to v_{HH} (wind speed at hub height)
- Uncertainty information
- IEC 61400-11 and IEC/TS 61400-14 additional information

2 2.5-103 Product Normal Operation Acoustic Performance

2.1 2.5-103 Normal Operation Calculated Apparent Sound Power Level

The Table 1 provides nominal acoustic specifications for 2.5-103 equipped with 103 m rotor diameter (GE 50.2 type blade) and 100 m hub height as function of wind speed v_{10m} (reference wind speed 10 m above ground level), operating at normal operation (NO) per IEC 61400-11 standard and GE's "Machine noise performance test" reference guidelines:

Wind speed at v_{10m} [m/s]	$L_{WA,k}$* Apparent sound power level [dB]
≤ 5	≤ 97.1
5.5	99.7
6	≤ 102.0
6.5	≤ 103.4
7	≤ 104.0
8	≤ 104.0
9	≤ 104.0
10-cut-Out	≤ 104.0

Table 1: Normal operations, 2.5-103 wind turbine, 50.2 m blades (103 m rotor), 100 m hub height, apparent sound power level at wind speed v_{10m}.

At wind speeds lower than 5 m/s the sound power levels decreases, and may get so low that the wind turbine noise becomes indistinguishable from the background noise. For a conservative calculation the data at 5 m/s may be used.

At wind speeds above 9 m/s turbine has reached rated power and the increasing pitch angle decreases the noise level. For a conservative calculation the data at 9 m/s may be used.

The nominal acoustic performances for **2.5-103**, 60 Hz version, equipped with 103 m rotor diameter (GE 50.2 type blade) operating in **normal operation** (NO), specified at **95 % rated electrical power**:

- The calculated apparent sound power level is $L_{WA,k}$ ≤ 104.0dBA.

* $L_{WA,k}$ indicates apparent sound power level per IEC-61400-11 standard measured in dB, A-weighted 10 base logarithmic value of apparent sound power relative to reference sound power of 10^{-12} W.

2.2 2.5-103 Normal Operation Calculated Tonality

The nominal acoustic performance for **2.5-103**, 60 Hz version, equipped with 103 m rotor diameter (GE 50.2 type blade) operating in **normal operation** (NO), specified at reference ground measuring distance $\mathbf{R_o}$ measurement position #1 per both IEC 61400-11 and GE's "Machine noise performance test" reference guidelines:

- Tonal audibility $\mathbf{\Delta L_{a,k} < 2\ dB}$.

3 2.5-103 Product Additional Information

3.1 2.5-103 Wind Speeds at Reference Height extrapolated to Hub Height

The wind speeds v_{10m} at reference height (10 m above ground) can be extrapolated from v_{10m} to v_{HH} (wind speed at hub height), per IEC 61400-01, assuming surface roughness of $z_{0,ref} = 0.05$ m typical average condition and using:

$$V_{10m\ height} = V_{hub} \frac{\ln\left(\frac{10m}{z_{0ref}}\right)}{\ln\left(\frac{hub\ height}{z_{0ref}}\right)}$$

Meaning wind speeds from Table 1 can be extrapolated to 100 m hub height using $\mathbf{v_{HH} = v_{10m} * 1.43}$ and to 85 m hub height using $\mathbf{v_{HH} = v_{10m} * 1.40}$ per Table 2.

Wind speed at 10 m reference height v_{10m} [m/s]	Wind speed at 85 m hub height $V_{HH=85}$ [m/s]	Wind speed at 100 m hub height $v_{HH=100}$ [m/s]
≤ 5	≤ 7.0	≤ 7.2
5.5	7.7	7.9
6	8.4	8.6
6.5	9.1	9.3
7	9.8	10.0
8	11.2	11.5
9	12.6	12.9
10-cut-out	13.7-cut-out	14-cut-out

Table 2: Relation between wind speed at reference height v_{10m} and wind speeds at different hub heights v_{HH} for $z_{0,ref} = 0.05$ m

3.2 2.5-103 Testing Uncertainty and Product Variation per IEC/TS 61400-14

Per IEC/TS 61400-14, $\mathbf{L_{WAd}}$ is the maximum apparent sound power level resulting from ***n*** measurements performed according to IEC 61400-11 standard for 95 % confidence level: $L_{WAd} = \overline{L_{WA}} + K$, where $\overline{L_{WA}}$ is the mean apparent sound power level from ***n*** IEC 61400-11 testing reports and $\mathbf{K = 1{,}645 \cdot \sigma_T}$.

The testing standard deviation values σ_T, σ_R and σ_P for measured apparent sound power level are described by IEC/TS 61400-14, where σ_T is the total standard deviation, σ_P is the standard deviation for product variation and σ_R is the standard deviation for test reproducibility.

Assuming σ_R **< 0.8 dB** and σ_P **< 0.8 dB** typical values, leads to calculated **K < 2 dB** for 95 % confidence level.

3.3 IEC 61400-11 and IEC/TS 61400-14 Terminology

- $L_{WA,K}$ is wind turbine apparent sound power level (referenced to 10^{-12}W) measured with A-weighting as function of reference wind speed v_{10m}. Derived from multiple measurement reports per IEC 61400-11, it is considered as a mean value
- σ_P is the product variation i.e. the 2.5-103 unit-to-unit product variation; typically < 0.8 dB
- σ_R is the overall measurement testing reproducibility as defined per IEC 61400-11; typically < 0.8 dB with adequate measurement conditions and sufficient amount of data samples
- σ_T is the total standard deviation combining both σ_P and σ_R
- $K = 1{,}645 \cdot \sigma_T$ is defined per IEC/TS 61400-14 for 95 % confidence level
- R_o is the ground measuring distance from the wind turbine tower axis per IEC 61400-11
- $\Delta_{La,k}$ is the audibility according to IEC 61400-11, described as potentially audible narrow band sound

References:

- IEC 61400-1, Wind turbines – part 1: Design requirements, ed. 3, 2005-08
- IEC 61400-11, wind turbine generator systems part 11: Acoustic noise measurement techniques, ed. 2.1, 2006-11
- IEC/TS 61400-14, Wind turbines – part 14: Declaration of apparent sound power level and tonality values, ed. 1, 2005-03
- MNPT – Machine Noise Performance Test, Technical documentation, GE 2007