Wind Turbine Generator System

Acoustic Noise Test Plan

for the

Alstom ECO100 60Hz 3MW Wind Turbine

in
Golden Colorado

by
National Wind Technology Center
National Renewable Energy Laboratory
1617 Cole Boulevard
Golden, Colorado 80401

for
Alstom Ecotecnia
Roc Boronat, 78. 08005
Barcelona, Spain

A. Huskey

February 2011

Approval By: Arlinda Huskey 02/28/2011
Arlinda Huskey, NREL Test Engineer — Date

Approval By: 02/17/2011
Ignasi Simon Torrens, Alstom Project Manager — Date

1.0 Test Objective

The primary goal of the test is to characterize the acoustic emissions of the Alstom ECO100 wind turbine in accordance with the International Electrotechnical Commission's (IEC) standard, *Wind turbines part 11: Acoustic Noise Measurement Techniques*, IEC 61400-11, Edition 2.1, 2006-11. Hereafter this standard is referred to as the Standard. This test plan documents the measurement techniques, test equipment, and analysis procedures for the following quantities:

- apparent sound power level,
- dependence on wind speed,
- third octave band levels, and
- tonality.

In addition, the National Wind Technology Center (NREL) plans to conduct this test in accordance with our quality system procedures such that the final test report will meet the full requirements of our accreditation by A2LA. NREL's quality system requires that we meet all applicable requirements specified by A2LA and ISO/IEC 17025 or to note any exceptions in the test report.

After approval, this test plan represents a commitment by both NREL and DOE to conduct the test according to the methods described herein.

2.0 Test Turbine

The test turbine will be an ECO100 wind turbine. Table 1 provides the key descriptive information of the test turbine.

Table 1. Test Turbine Configuration

Turbine manufacturer and address	Alstom Wind Roc Boronat, 78. 08005 Barcelona, Spain
Model	ECO100 60Hz 3MW
Serial number	B019 / 1 / 041
Rotor Diameter (m)	100.8
Hub Height (m)	90
Horizontal distance from rotor center to tower axis (m)	2.824
Stall or pitch-controlled	Pitch-controlled
Tower Type	Tubular
Rated Electrical Power (kW)	3000
Rated Wind Speed (m/s)	12
Rotor speed range (rpm)	8.1 – 14.2
Rotor control devices	none
Number of Blades	3
Blade Tip Pitch Angle (deg)	Variable
Blade make, type, serial number	LM48.8 P
Description of control system (device & software version)	Galileo, TBD

3.0 Test Site

The test turbine is located at site 4.1 at the National Wind Technology Center, 8 miles south of Boulder, Colorado, USA. Figure 1 shows the turbine and meteorological tower locations. This figure also shows nearby obstructions and topographical features of the site.

Nearby sources of noise that might interfere with noise testing of the test turbine are given in Table 2

Table 2. Nearby noise sources

Source	Location	Shutdown for noise test
GE 1.5	4.0	Yes
CART3	4.3	Yes
CART2	4.3	Yes
Siemens 2.3MW	4.4	As needed
Swift 1kW	3.1	No
Southwest Windpower Skystream (2 turbines)	3.2	No
Ventera 10kW	3.3	No
Entegrity EW50	1.E1	As needed

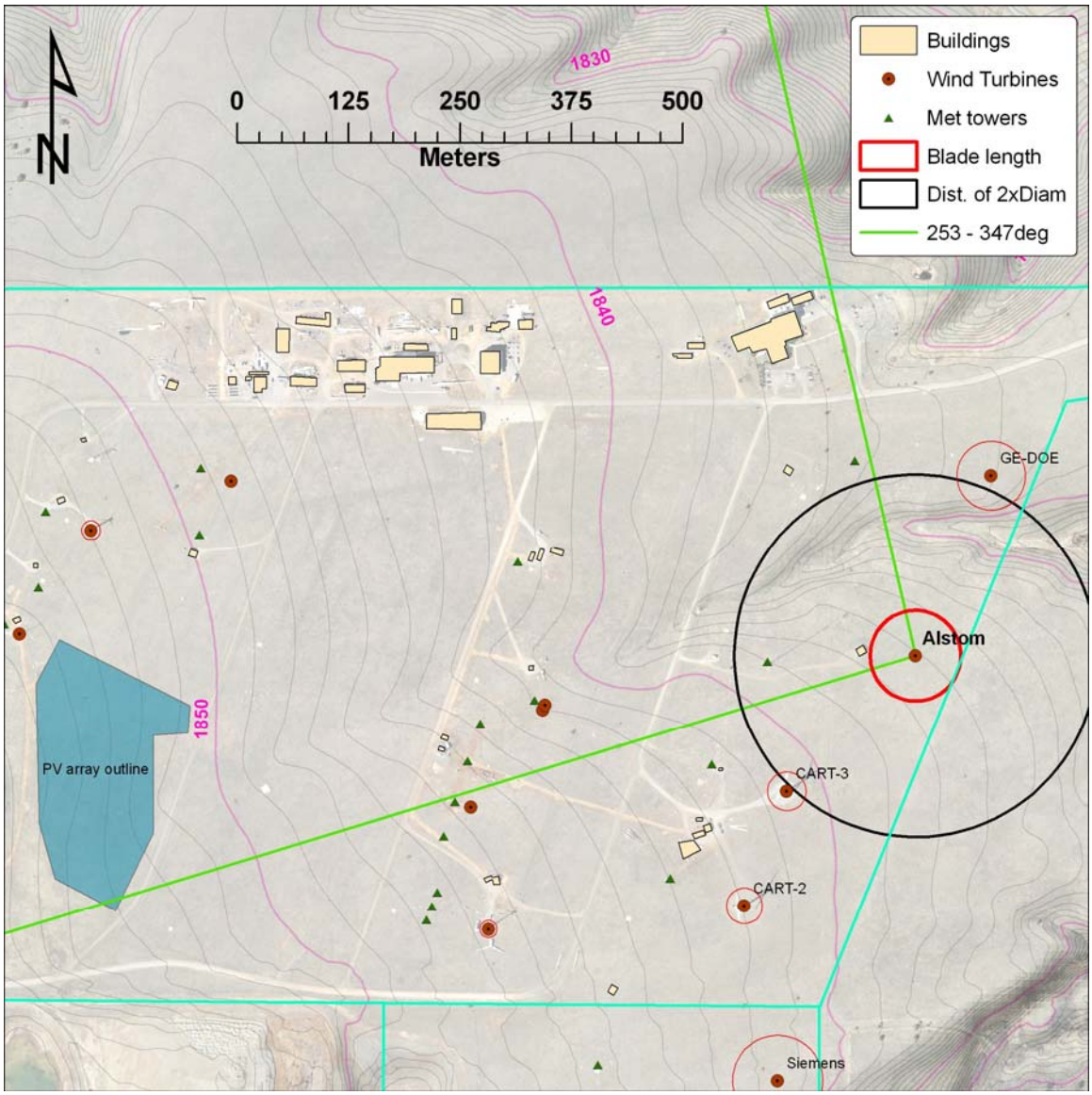

Figure 1. Test Turbine Location

4.0 Test Instrumentation

Table 3 shows the list of instrumentation that will be used for the test. The wind speed will be derived from the turbine power output or nacelle anemometer for total noise measurements (turbine plus background). For background noise measurements, the wind speed will be measured on a temporary 10 meter tall met tower and correlated with wind speed derived from turbine power. A microphone with wind screen will be placed in the downwind reference position to measure the total and background noise.

Table 3. Equipment list

Instrument	Manufacturer	Model Number
Signal Analyzer	Delta Acoustics	Noiselab Professional 3.0
Microphone	Bruel & Kjaer	4189-A-021
Preamplifier	Bruel & Kjaer	4012
Calibrator	Bruel & Kjaer	4230
Digital Recorder	Delta Acoustics	Noiselab Professional 3.0
Meteorological anemometer	Vector	A100L2
Nacelle anemometer	NRG	Ice Free Hybrid
Wind Vane	Met One	SD-201
Pressure Sensor	Vaisala	PTB101B
Temperature Sensor	Met One	T200
Power	Ohio Semitronics Instruments	Rotor: PT: DWV-008D CT: MLG-TP812 Stator: PT: DWV-007D CT: MLG-TP816 VT: LEM CV3-1500 Consumption: PT: DWV-008D CT: MLG-TP58
Meteorological Data Acquisition System	National Instruments	EtherCAT
Pitch angle	Alstom controller	
Rotor speed	Alstom controller	
Power	Alstom controller	

5.0 Test Procedures

Testing will begin once three conditions are fulfilled:

1. This test plan is complete and signed by both the client and NREL
2. NREL has complete installation and checkout of meteorological instrumentation required for the test
3. The client has signed a test readiness document that indicates that the turbine is ready for testing.

The test will continue until all requirements listed in Table 4 are fulfilled.

Table 4. Data Requirements for Acoustics test

Measurement Type	Requirements
Overall measurements	At least 30 one-minute averages.
For A-weighted sound pressure level: (for turbine and background measurements)	At least 3 minutes of data with wind speeds ±0.5 m/s of the integer values of 6, 7, 8, 9, and 10 m/s
For octave or third octave band measurements:	At least 3 minutes of data with wind speeds ±0.5 m/s of the integer values of 6, 7, 8, 9, and 10 m/s
Narrow band measurements:	At least 2 minutes of data with wind speeds ±0.5 m/s of the integer values of 6, 7, 8, 9, and 10 m/s

6.0 Reporting

The final report will include:

1. Description of the test turbine
2. Description of the test site
3. Description of the test instrumentation
4. Description of the measurement procedure
5. Results with uncertainty including:
    a. A-weighted sound power level (as function of standardized wind speed, rotor speed and power)
    b. Plots of all data and regression lines
    c. One-Third Octave Spectra (graphically and tabularly)
    d. Tonal analysis
6. Exceptions to the requirements of the IEC standard, test plan or NREL quality system

7.0 Roles and Responsibilities

Table 5 lists the planned test team, and identifies roles and responsibilities for each team member.

Table 5. Roles of Test Participants

Title	Name	Role(s)
Test Engineer	Arlinda Huskey NREL	Overall test management and responsibility. NREL approval of test plan. Supervision of test set-up, checkout, and conduct. Collection of test data. Analysis of test data Resolution of problems during testing Review and report test results. Final report
Test Technician	Jerry Hur NREL	Selection of instruments Installation, maintenance and checkout of test equipment Implementation of corrective actions for problems Responsible for ensuring safety of personnel and equipment at test site.
Turbine technician	Brian Smyla Alstom	Operation and maintenance of test turbine (under supervision of site manager).
Client	Ignasi Simon Torrens Alstom	Approve test plan Primary turbine manufacturer contact for NREL Provided information needed for test plan Reports any change in turbine configuration to NREL Resolution of any problems with test turbine Provides test evaluation to NREL