	Emergya Wind Technologies BV
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Specification

DIRECTWIND 52/54*900 Technical Specification

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Contents

1 Introduction

This document provides a technical overview of the *DIRECTWIND* 52/54*900 Wind Turbine designed for the IEC class II/III application. It is to be read in conjunction with document S-1000921 "Directwind 52/54*900 Electrical Specification".

2 Technical Description

The *DIRECTWIND* 52/54*900 is a direct-drive, variable speed, pitch regulated, horizontal axis, three-bladed upwind rotor wind turbine.

The gearless direct-driven synchronous generator operates at variable speed. This is made possible by an actively controlled AC-DC-AC IGBT power converter connected to the grid. Benefits of this design are low maintenance, constant power output at wind speed above rated, and relatively low structural loads compared to constant-speed stall-controlled or constant-speed pitch-controlled wind turbines.

The generator is fully integrated into the structural design of the turbine, which allows for a very compact nacelle design. The drive-train makes use of only one main bearing, whereas classic designs have separately supported main shaft, gearbox and generator. All dynamically loaded interfaces from the blades to the foundation are sturdy flange connections with machined surfaces, and high tensile steel pre-stressed bolt connections are used.

2.1 Operation and safety system

The turbine operates automatically under all wind conditions and is controlled by an industrial PLC (Programmable Logic Controller). The cut-in wind speed is approximately 3m/s. When the rotational speed reaches the cut-in threshold, the power converter begins to deliver power to the grid.

The power converter controls the generator power output and is programmed with a power set-point versus rotor speed curve. Below rated wind speed the power output is controlled to optimise rotor speed versus aerodynamic performance (optimum λ-control). Above rated wind speed the power output is kept constant at rated value by PD-controlled active blade pitching.

The dynamic responses of the drive train and power controller are optimised for high yield and negligible electrical power fluctuations. The variable speed rotor acts as a flywheel, absorbing fluctuating aerodynamic power input. The turbine controllers are located in the rotor hub and the tower base (with remote IO in the nacelle) and carry out all control functions and safety condition monitoring. In the case of a fault, or extreme weather conditions, the turbine is stopped by feathering of the blades to vane position (blades swivelled to 90^0 with respect to rotor's rotational plane). In case of power loss, an independent battery backup system in each blade ensures the blades are feathered.

In the case of less serious faults which have been resolved, or when extreme weather conditions have passed, the turbine restarts automatically to minimise downtime.

2.2 Generator

The multiple-pole, direct-drive generator is directly mounted to the hub. The stator is located in the non-moving outer ring and the wound pole, separately excited rotor rotates on the inner ring.

The generator is designed such that all aerodynamic forces are directly transferred to the nacelle construction without interfering with the generator-induced loads.

2.3 Power Converter

The power converter is an AC-DC-AC IGBT active switching converter. It controls the generator to operate in its optimum range, and maintains power quality to the grid. The inverter can produce unity power factor (cosΦ=1) to the grid under all load conditions. Power factor is also controllable within limits.

2.4 Rotor

The rotor is a three bladed construction, mounted up-wind of the tower. Rotational speed is regulated by active blade adjustment towards vane position. Blade pitch is adjusted using an electric servomotor on each of the blades.

Each blade has a complete, fully independent pitch system that is designed to be fail-safe. This construction negates the need for a mechanical rotor brake. The pitch system is the primary method of controlling the aerodynamic power input to the turbine.

At below rated wind speed the blade pitch setting is constant at optimum aerodynamic efficiency. At above rated wind speed the fast-acting control system keeps the average aerodynamic power at the rated level by keeping the rotor speed close to nominal, even in gusty winds.

The rigid rotor hub is a nodular cast iron structure mounted on the main bearing. Each rotor blade is connected to the hub using a pre-stressed ball bearing. It is sufficiently large to provide a comfortable working environment for two service technicians during maintenance of the pitch system, the three pitch bearings and the blade root from inside the structure.

2.5 Rotor blade set

The rotor blades are made of fibreglass-reinforced epoxy. The aerodynamic design represents state-of-the-art technology and is based on a pitch-regulated concept. No extenders are used and the aerodynamic design is optimal for this rotor diameter.

2.6 Main bearing

The large-diameter main bearing is a specially designed three row cylindrical roller bearing. The inner non-rotating ring is mounted to the generator stator. The outer rotating ring is mounted between the hub and generator rotor. The bearing takes axial and radial loads as well as bending moments. Entrance to the hub is through the inner-bearing ring. The bearing is greased by a fully automatic lubrication system controlled by the turbine PLC.

2.7 Nacelle

The nacelle is a compact welded construction which houses the yaw mechanism, a service hoist and a control cabinet. Both the generator and the tower are flanged to the nacelle. The geometry of the construction assures an ideal transfer of loads to the tower and, with the absence of a shaft and gearbox, results in a simple design ensuring easy personnel access.

2.8 Yaw system

The yaw bearing is an internally geared ring with a pre-stressed four point contact ball bearing. Electric planetary gear motors yaw the nacelle. The yaw brake is passive and is based on the friction of brake pads sitting directly on the bearing ring, keeping the yaw system rigid under most loading conditions.

2.9 Tower

The nacelle assembly is supported on a tubular steel tower, fully protected against corrosion. The tower allows access to the nacelle via a secure hinged access door at its base. The tower is fitted with an internal ladder with safety wire and optional climb assistance, rest platforms and lighting. Standard hub heights are 35, 40, 50 and 75 metres.

2.10 Anchor

The turbine is supported by a concrete foundation. The connection to this foundation is provided by means of a cast-in tube or rod anchor.

2.11 Control System

2.11.1 Bachmann PLC

The M1 controller perfectly combines the openness of a PC-based controller with the reliability of industrial hardware platforms. Designed to withstand the toughest ambient conditions it guarantees error-free use over long periods of time.

A modern system architecture designed for consistent network-capability permits the easy integration of the M1 into the environment of the controller and system peripherals. Real-time ethernet permits the real-time networking of the controllers, and the support of all standard Fieldbus systems permits the connection of standard external components.

2.11.2 DMS

DIRECTWIND Monitoring System – EWT's proprietary HMI featuring local monitoring and control at the turbine, integrated into a remote-access SCADA. DMS offers individual turbine control and total park monitoring and data logging from your Wind Turbine, Wind Park or internet access point.

2.12 Earthing and lightning protection

The complete earthing system of the wind turbine incorporates:

1. Protective earthing:
   A PE connection ensures that all exposed conductive surfaces are at the same electrical potential as the surface of the Earth, to avoid the risk of electrical shock if a person touches a device in which an insulation fault has occurred. It ensures that in the case of an insulation fault (a "short circuit"), a very high current flows, which will trigger an over-current protection device (fuse, circuit breaker) that disconnects the power supply.

2. Functional earthing:
   Earthing system to minimize and/or remove the source of electrical interference that can adversely affect operation of sensitive electrical and control equipment.

   A functional earth connection serves a purpose other than providing protection against electrical shock. In contrast to a protective earth connection, the functional earth connection may carry electric current during the normal operation of the turbine.

3. Lightning protection:
   To provide predictable conductive path for the over-currents in case of a lightning strike and electromagnetic induction caused by lightning strike and to minimize and/or remove dangerous situations for humans and sensitive electrical equipment.

Since the mechanical construction is made of metal (steel), all earthing systems are combined.

2.13 Options

The following options are available:

- Cold climate operation (rated for operation down to -40°C)
- Ice detection and/or prevention system
- Aviation lights
- Shadow flicker prevention
- Low Voltage Ride-through (LVRT)
- Service lift (75m tower only)
- G59 protection relay

3 Technical Data

Where data are separated by "/" this refers to the respective rotor diameter (52 / 54 m).

3.1 Wind and Site Data

Wind class	II / III according to IEC 61400 – 1
Max 50-year extreme	59.5 / 52.5 m/s
Turbulence class	A (I_{15} = 0.16)
Maximum flow inclination (terrain slope)	8°
Max ann. mean wind speed at hub height	8.5 / 7.5 m/s
Nominal air density	1.225 kg/m³

3.2 Operating Temperature

	Standard	Cold Climate
Min ambient operating	-20°C	-40°C
Max ambient operating	+40°C	+40°C

3.3 Cooling

Generator cooling	Air cooled
Converter cooling	Water or air cooled (configuration-dependent)

3.4 Operational Data

Cut in wind speed	3 m/s
Cut out wind speed	25 m/s
Rated wind speed	14 / 13.5 m/s
Rated rotor speed	26 rpm
Rotor speed range	12 to 33 rpm
Power output	900kW
Power factor	1.0 (adjustable 0.95 lagging to 0.95 leading) Measured at LV terminals

3.5 Rotor

Diameter	52 / 54 m
Type	3-Bladed, horizontal axis
Position	Up-wind
Swept area	2,083 / 2,290 m²
Power regulation	Pitch control; Rotor field excitation
Rotor tilt angle	5°

3.6 Blade Set

Type	PMC 24.5 / 25.8
Blade length	24.5 / 25.8 m
Chord at 22.0 m	0.879 m (90% of 24.5m blade radius)
Chord at 23.5 m	0.723 m (90% of 25.8m blade radius)
Chord Max at 5.5 m	2.402 m
Aerodynamic profile	DU 91, DU 98 and NACA 64618
Material	Glass reinforced epoxy
Leading edge protection	PU coating
Surface colour	Light grey RAL 7035
Twist Distribution	11.5^0 from root to 5.5m then decreases linearly to 0.29^0, then non-linearly to 0^0

3.7 Transmission System

Type	Direct drive
Couplings	Flange connections only

3.8 Controller

Type	Bachmann PLC
Remote monitoring	DIRECTWIND Monitoring System, proprietary SCADA

3.9 Pitch Control and Safety System

Type	Independent blade pitch control
Activation	Variable speed DC motor drive
Safety	Redundant electrical backup

3.10 Yaw System

Type	Active
Yaw bearing	4 point ball bearing
Yaw drive	3 x constant speed electric geared motors
Yaw brake	Passive friction brake

3.11 Tower

Type	Tapered tubular steel tower
Hub height options	HH = 35, 40, 50, 75 m
Surface colour	Interior: White RAL 9001, Exterior: Light grey RAL 7035

3.12 Mass Data

Hub	9,303 kg
Blade – each	1,919 / 1,931 kg
Rotor assembly	15,060 / 15,096 kg
Generator	30,000 kg
Nacelle assembly	10,000 kg
Tower HH35	28,300 kg
Tower HH40	34,000 kg
Tower HH50	46,000 kg
Tower HH75	86,500 kg

3.13 Service Brake

Type	Maintenance brake
Position	At hub flange
Calipers	Hydraulic 1-piece

APPENDIX 1: 3D image of main turbine components