REGIONE BASILICATA

PARCO EOLICO SERRA GAGLIARDI
GENZANO DI LUCANIA (PZ)

ELABORATO DI PROGETTO

2					
1					
0	15/05/2010	Ing. M.Martellucci	Ing. M.Martellucci	Ing. F. Di Chiappari	
Em./Rev.	**Data**	**Red./Dis.**	**Verificato**	**Approvato**	**Descrizione**

Redazione: **SKYWIND S.r.l.** via Marconi, 6, 04024 Gaeta (LT)

Titolo dell'allegato:

Piano di manutenzione e gestione dell'impianto

Pagine: *1 di 64*

Doc.n°: **B**

Committente:

SKYWIND

S.r.l. Via Marconi, 6
04024 Gaeta (LT) **ITALY**

Indice:

B. PIANO DI MANUTENZINE E GESTIONE DELL'IMPIANTO

B.1.a. Parte Generale

- Lista anagrafica dei componenti dell'impianto
- *Schede tecniche dei componenti dell'impianto.*
- Schemi di funzionamento dei componenti dell'impianto

B.1.b. Sistema di manutenzione dell'impianto

- Salvaguardia delle prestazioni tecnologiche ed ambientali, dei livelli di sicurezza e di efficienza iniziali dell'impianto;
- Minimizzare dei tempi di non disponibilità di parti dell'impianto durante l'attuazione;
- Lista anagrafica dei componenti dell'impianto;
- Rispetto delle disposizioni normative.

B.1.c. Manuale D'uso Di Tutti I Componenti Dell'impianto

- Individuazione e descrizione delle modalità di corretto funzionamento dei componenti e delle operazioni manutentive che non richiedono competenze specialistiche (verifiche, pulizie, regolazioni, ecc…);
- Individuazione dei principali sintomi indicatori di anomalie e guasti, imminenti o in atto.

B.1.d. Manuale di manutenzione dell'impianto

- *Individuazione, descrizione dettagliata ed istruzioni operative degli interventi di manutenzione ordinarie e straordinaria per ogni componente dell'impianto;*
- *Descrizione delle risorse necessarie per l'intervento manutentivo di manutenzione; le istruzioni operative dettagliate per la manutenzione, che deve eseguire il tecnico.*

B.1.E. Programma di manutenzione

- *Individuazione e descrizione dettagliata del sistema dei controlli e degli interventi da eseguire al fine di una corretta conservazione e gestione dell'impianto nella sua totalità e nelle sue parti;*
- *Individuazione e descrizione dettagliata delle scadenze temporali per tutte le operazioni di manutenzione;*
- *Definizione dei fabbisogni di manodopera (specializzata e non) e delle altre risorse necessarie.*

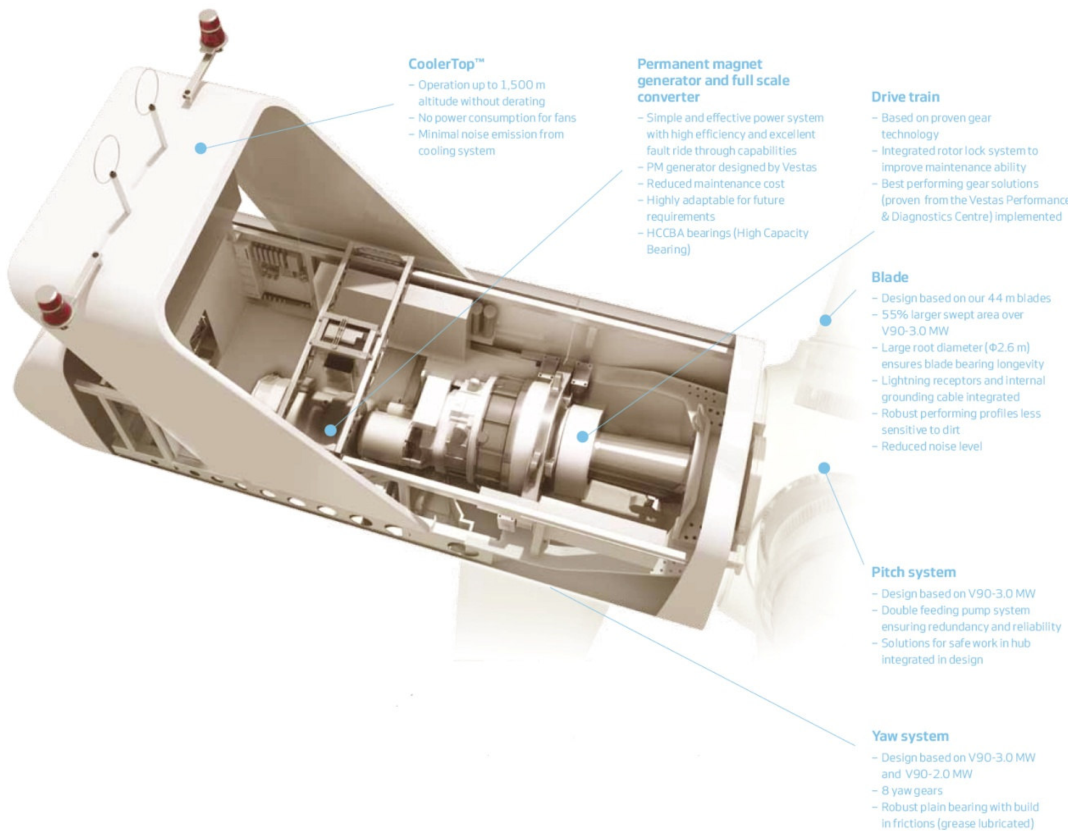
B. PIANO DI MANUTENZINE E GESTIONE DELL'IMPIANTO

B.1.a. Parte Generale

- **Lista anagrafica dei componenti dell'impianto**

Elementi dell'aerogeneratore

La figura sottostante raffigura i vari componenti nella cabina dell'aerogeneratore:



Rotore

La V112-3.0 MW è equipaggiata da un rotore di 112 metri di diametro costituito da tre pale ed un mozzo. Le pale sono controllate da un sistema di

controllo chiamato OptiTip ®. In base alle condizioni del vento, le pale vengono continuamente posizionate per ottimizzare l'angolo di attacco.
Il rotore ha un angolo di inclinazione di 2° per garantire che la punta della pala non interferisca con la torre.

Pale

Le pale sono lunghe 56 m con una larghezza massima di 4 m.
Sono realizzate in fibra di vetro rinforzata con fibre di carbonio e resina epossidica e sono costituite da due gusci alari fissati ad una trave portante.

Mozzo

Il mozzo ha una forma sferica ed è fabbricato in fusione nodulare. Si monta direttamente sull'asse principale. Presenta un'apertura frontale per consentire l'accesso e la manutenzione, finalizzata, quest'ultima, al controllo della coppia sui bulloni di ancoraggio delle pale.

Rotore – Cono

Il cono protegge il mozzo y gli ancoraggi Della pala dall'ambiente esterno. Il cono si ancora alla parte frontale del mozzo.

Rotore – Ingranaggi delle pale

Permettono il cambio di passo della pala (pitch control) e garantiscono la connessione tra la pala e il mozzo.

Rotore – Sistema cambio di passo

Il sistema si aziona durante tutta la vita utile dell'aerogeneratore:

- quando la velocità del vento è inferiore alla nominale, l'angolo di passo selezionato dal sistema sarà quello di massima potenza elettrica relativa a quella velocità del vento;
- quando la velocità del vento è superiore alla nominale, l'angolo di passo è quello che proporziona la potenza nominale della macchina.

Il movimento del sistema garantisce la rotazione di ciascuna pala lungo il proprio asse principale. Per azionare il sistema si adopera un sistema idraulico che aziona tre cilindri idraulici per ciascuna pala.

Asse principale

La trasmissione Della coppia motore che provoca il vento sul moltiplicatore, avviene grazie all'asse principale. L'asse è un mozzo con una brida bullonata ed è appoggiato su supporti che assorbono i carichi trasversali del rotore.
Questi supporti si interfacciano con l'asse con dei cuscinetti. La giunzione con l'asse lento del moltiplicatore si realizza con un disco conico che trasmette la coppia attraverso una frizione.

Telaio

La progettazione del telaio è meccanicamente semplice e finalizzata a renderlo robusto per sopportare gli elementi della gondola e trasmettere i carichi fino alla torre.
La trasmissione di questi carichi si realizza attraverso il cuscinetto della corona di orientazione (yaw control).
Il telaio si divide in parti:

- La parte anteriore consiste in due pezzi fusi insieme e collegata ai supporti dell'asse principale e della corona di orientazione attraverso un sistema di bulloni.
- La parte inferiore è formata da due putrelle. Tale parte è stata progettata per sopportare gli sforzi provenienti dal generatore, del trasformatore e del controller.

Tra tali putrelle c'è un'apertura che consente l'accesso all'interno della gondola per l'esecuzione delle operazioni di riparazione e manutenzione.

Carter di copertura

E' la coperta che protegge i componenti dell'aerogeneratore, interni alla gondola ed è fabbricata in resina poliestere e fibra di vetro.

All'interno della gondola c'è spazio sufficiente per le riparazioni e la manutenzione dell'aerogeneratore. Una botola nella parte frontale permette l'accesso all'interno del cono e una botola nella parte inferiore consente di operare con una gru. Il lucernario sul tetto proporziona luce solare durante il giorno, ventilazione aggiuntiva e accesso all'esterno, dove si trovano gli strumenti di misura del vento e il parafulmine. Le parti in rotazione sono debitamente coperte per proteggere i manutentori.

Misura del vento

All'esterno della cappotta, nella parte superiore, due bracci verticali in metallo servono da supporto degli anemometri sonici per la misura del vento.

Sistema di controllo

Il sistema di controllo monitorizza e governa tutte le funzioni dell'aerogeneratore in modo che le condizioni di avvio siano ottime in tutti gli istanti.

Il sistema di controllo registra continuamente i segnali dei diversi sensori dell'aerogeneratore e quando segnala qualche errore, avvia le azioni opportune per compensarlo. Il sistema di controllo governa l'aerogeneratore se l'errore individuato lo richiede.

Il sistema è dotato di una interfaccia touch-screen dove appaiono i dati di operazione e che consente l'interazione con l'aerogeneratore. E' presente anche un sistema di controllo preparato per il monitoraggio remoto qualora fosse necessario.

Dispositivi del sistema di controllo

Il sistema di controllo è costituito da tre armadi:

- controller navicella, all'interno della navicella stessa;
- controller ground, posizionato alla base della torre;
- controller del mozzo, posizionato nella parte rotatoria dell'aerogeneratore.

A sua volta, il controller navicella si divide in tre parti:

- sezione di controllo: monitorizza il vento, il cambio di passo, l'orientazione, la temperatura interna ecc…;
- convertitore di frequenza:controlla la potenza, gestisce la connessione e sconnessione del generatore alla rete;
- sezione di protezione e messa a terra: uscita della potenza generata con tutte le protezioni elettriche necessarie.

Finestra di controllo

Dalla finestra touch-screen presente alla base Della torre, si possono osservare i dati operativi dell'aerogeneratore, fermare e avviare la macchina, ecc… ed è possibile anche collegare un pc portatile per avviare le diverse operazioni.

Controllo dell'aerogeneratore

La velocità di rotazione dell'aerogeneratore e l'angolo di passo delle pale, variano in ogni istante, in funzione Della velocità del vento che arriva alla machina. Il sistema di controllo si occupa di selezionare i valori idonei di queste variabili.

Per quello che riguarda la velocità del vento, si possono stabilire quattro fasi:

1. Vento basso, con il generatore sconnesso dalla rete;
2. Vento medio con il generatore connesso alla rete, senza arrivare a generare potenza nominale;
3. Vento alto, il generatore produce la potenza nominale;
4. Vento molto alto, il generatore si sconnette e la turbina si ferma.

Vento basso

Quando la velocità del vento è inferiore a quella di avvio della macchina ma prossima a questa, il sistema di controllo riporta le pale ad un angolo vicino a 45°, posizione che proporziona una coppia di avvio abbastanza elevata.

Quando la velocità del vento aumenta, la velocità di rotazione del rotore aumenta in modo proporzionale e l'angolo di passo si riduce fino a che giungono le condizioni adeguate perché il generatore si connetta.

Vento medio

A velocità del vento al di sopra di quella di avvio e al di sotto della velocità nominale, il sistema di controllo seleziona la velocità di rotazione e l'angolo di passo che proporziona la massima potenza per ciascuna velocità del vento.

Vento elevato

Quando la velocità del vento è superiore a quella nominale, l'energia contenuta nel vento è sufficiente per produrre potenza nominale e l'angolo di passo aumenta per regolare la potenza al suo valore nominale.

Vento molto elevato

Se la velocità del vento è superiore alla velocità di fermata, il generatore si disconnette e il sistema di controllo porta le pale alla posizione di bandiera (vicina a 90°), fino a che la velocità del vento si abbassa al di sotto della velocità di riavvio e la macchina inizia nuovamente a generare potenza.

Comunicazione del trasformatore, armadio di controllo e cella – Alimentazione del rotore del generatore

L'alimentazione del rotore del generatore avviene attraverso un'uscita del trasformatore principale a 480 V.

Comunicazione del trasformatore, armadio di controllo e cella – Caratteristiche dei cavi del generatore

Statore: i cavi che uniscono lo statore del generatore con l'armadio di controllo di potenza, all'interno della navicella, sono cavi DN-K 0.6/1kV 3x240 mm_2 progettati seguendo le norme UNE 21150.

Si utilizzano 4 cavi in parallelo per alimentare lo statore. Per il rotore si utilizzato 4 cavi DN-K 0.6/1kV 3x70 mm2. I cavi che uniscono l'armadio di controllo di potenza con il trasformatore, sono cavi di tipo DN-K 0.6/1kV 1x240 mm2. Si utilizzano 4 cavi in parallelo per lo statore e uno per il rotore.

Comunicazione del trasformatore, armadio di controllo e cella – Fibra ottica

La fibra ottica utilizzata per le comunicazioni dell'aerogeneratore ha un diametro di 200/230 mm, 4 fili per manichetta. Questa fibra è protetta contro l'umidità e i roditori. Si utilizza per le comunicazioni tra i vari processori dell'aerogeneratore o tra questi e l'utente umano che si collega attraverso un terminale operativo. Il sistema di controllo a distanza utilizza anch'esso una fibra di diametro 62.5/125 mm, anch'essa protetta contro l'umidità e i roditori, per comunicare tra i vari aerogeneratori.

- ***Schede tecniche dei componenti dell'impianto.***

In seguito si riporta, in allegato (allegato n.1 "General Specification V112-3.0 50/60 Hz") la scheda tecnica dei componenti dell'impianto fornita direttamente dalla casa produttrice.

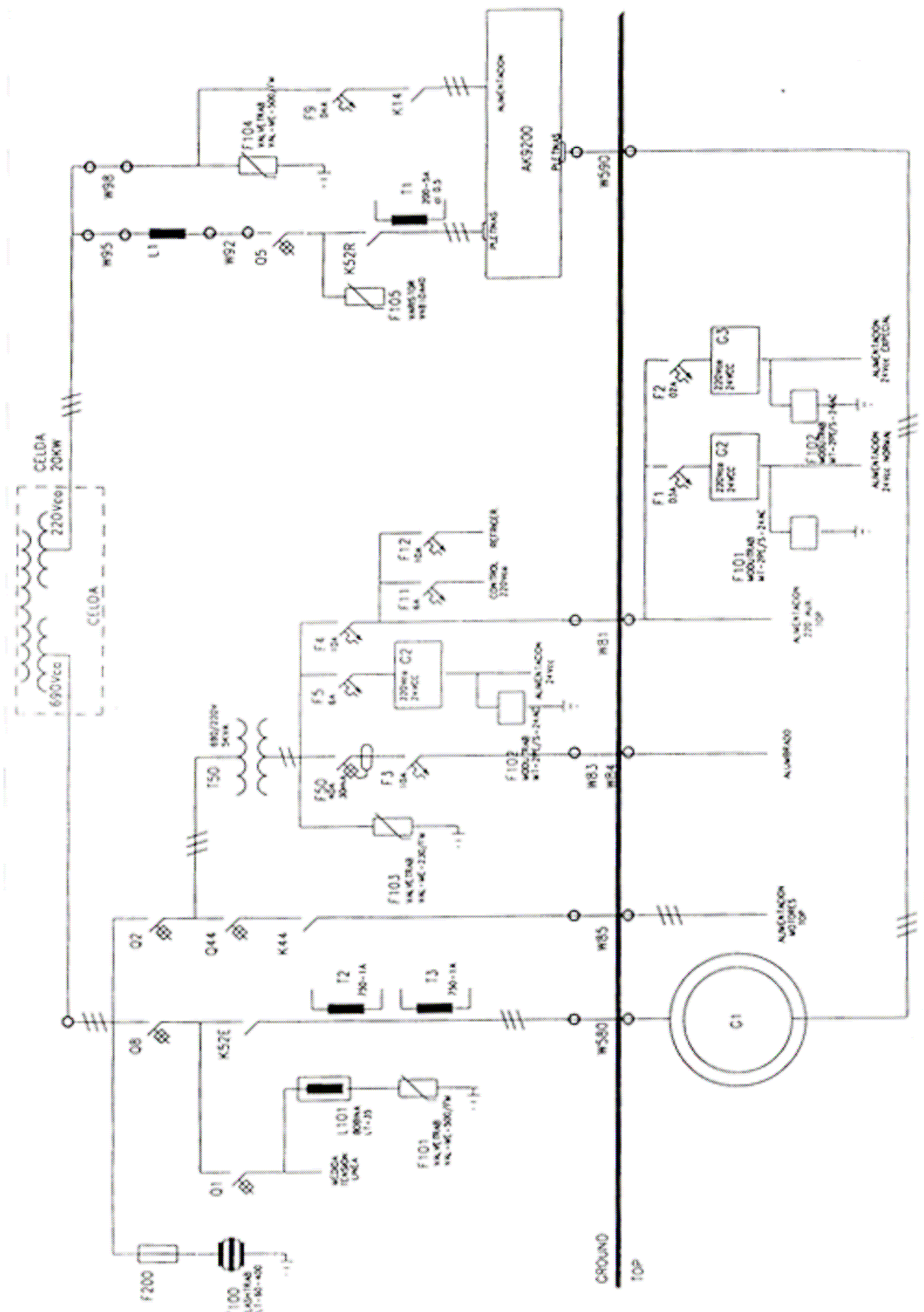
- **Schemi di funzionamento dei componenti dell'impianto**

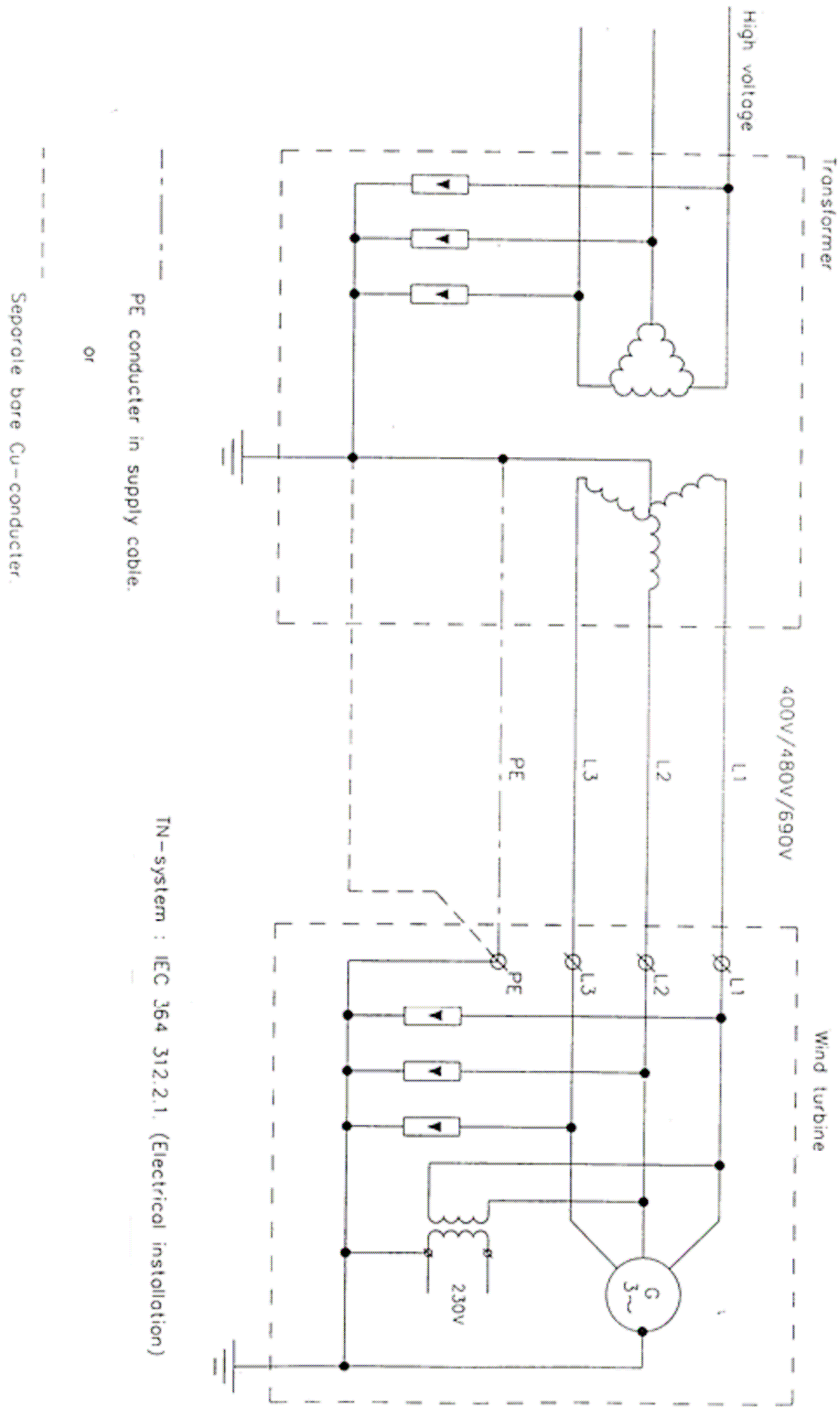
Un impianto eolico costituito da un numero di aerogeneratori collegati tra loro a mezzo di un cavidotto elettrico che ne assicura la continuità dell'impianto. L'energia convogliata nel cavidotto viene poi consegnata alla RTN. Le modalità di connessione di ciascun aerogeneratore all'altro, cambiano in funzione del layout di funzionamento scelto per l'impianto.

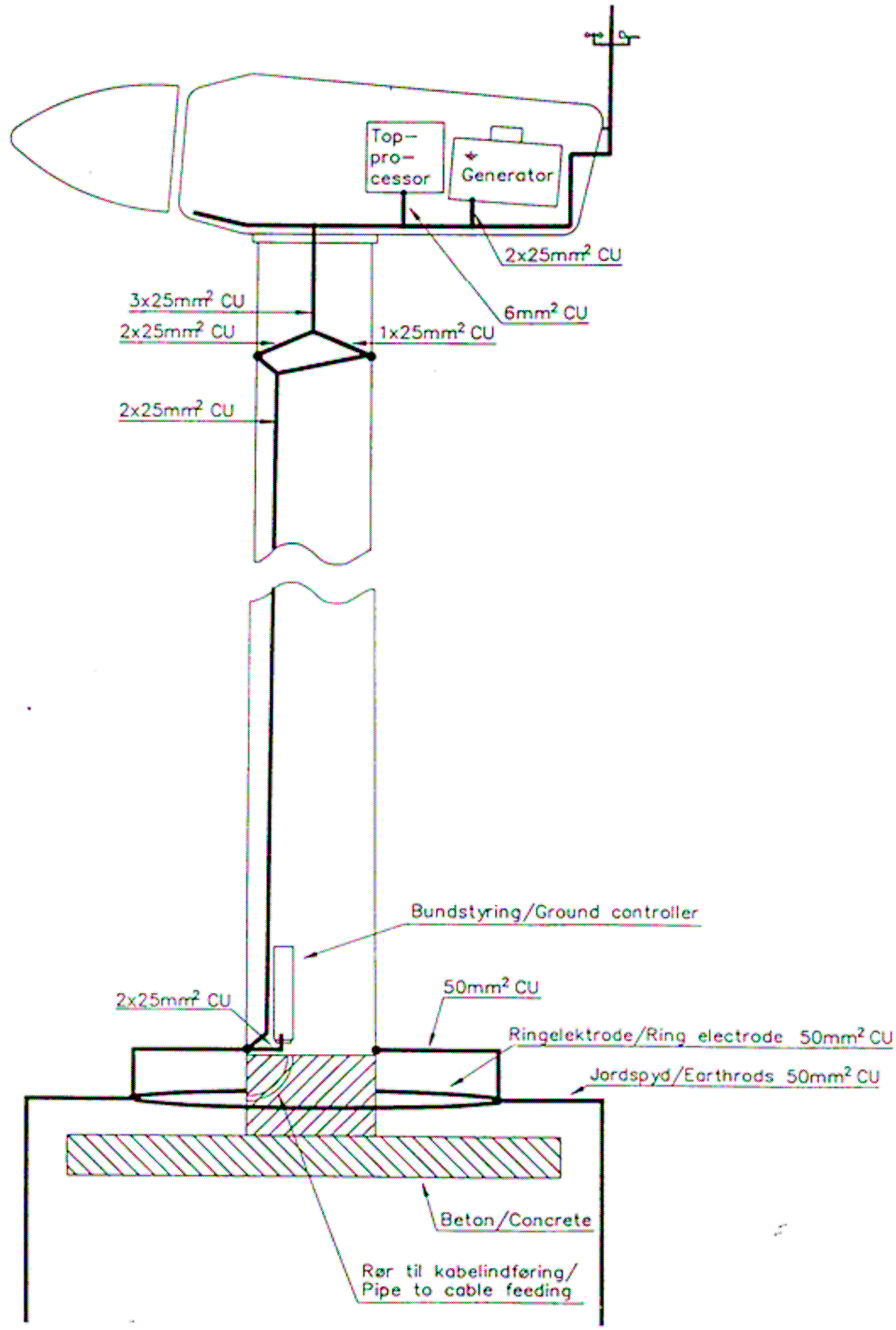
Ciascun aerogeneratore lavora in modo autonomo.

Quando la velocità del vento supera quella di avviamento, la macchina si avvia ed inizia a produrre energia fino a quando la velocità del vento non supera il

valore massimo ammesso, punto in cui la macchina entra in emergenza e si ferma, in attesa che il vento rientri nel rango di sfruttamento.
In particolare, quando la velocità del vento supera il valore di avviamento, il sistema idraulico di pitch ruota l'angolo d'attacco delle pale e le porta a circa 45°, garantendo la massima portanza. Avviato il moto rotatorio del rotore e raggiunta la velocità di giro necessaria all'avvio del generatore, la centrale inizia ad immettere energia in rete. L'asse principale, collegato da un lato al mozzo e dall'altro al moltiplicatore, poggia su due cuscinetti che ne attutiscono le vibrazioni trasmesse dal rotore.
Il moltiplicatore aumenta il numero di giri dell'asse lento e accende il generatore che genera energia in bassa tensione. L'energia, perché raggiunga il punto di consegna, deve trasformare la propria tensione al fine di ridurre al minimo le perdite per effetto Joule.
Il trasformatore ha questo compito e immette energia in media tensione nel circuito interno al parco eolico.
Il circuito idraulico, oltre a controllare l'angolo di passo (pitch), regola il sistema di orientazione della macchina, in modo da portare la macchina sempre sotto vento ed ottimizzare sforzi e produzione. I comandi vengono trasmessi dai due anemometri montati in cima alla cappotta. Tali sensori trasmettono i segnali ad un armadio di controllo che gestisce, attraverso un PLC, l'intera macchina.
Di seguito si riporta uno schema elettrico unifilare tipo che rappresenta le protezioni interne all'aerogeneratore e lo schema elettrico della messa a terra.


CELDA
20KW
690Vcc
220Vcc
GROUND
TOP
G1


High voltage
Transformer
400V/480V/690V
L1
L2
L3
PE
Wind turbine
G
3~
230V
TN-system : IEC 364 312.2.1. (Electrical installation)
PE conducter in supply cable.
or
Separate bare Cu-conducter.


Top–
pro–
cessor
Generator
2x25mm² CU
3x25mm² CU
6mm² CU
2x25mm² CU
1x25mm² CU
2x25mm² CU
Bundstyring/Ground controller
2x25mm² CU
50mm² CU
Ringelektrode/Ring electrode 50mm² CU
Jordspyd/Earthrods 50mm² CU
Beton/Concrete
Rør til kabelindføring/
Pipe to cable feeding

B.1.b. SISTEMA DI MANUTENZIONE DELL'IMPIANTO

Individuazione, descrizione e frequenza delle operazioni e delle attività di manutenzione ordinaria e straordinaria di tutti i componenti dell'impianto finalizzate a:

- Salvaguardia delle prestazioni tecnologiche ed ambientali, dei livelli di sicurezza e di efficienza iniziali dell'impianto;
- Minimizzare dei tempi di non disponibilità di parti dell'impianto durante l'attuazione;
- Lista anagrafica dei componenti dell'impianto;
- Rispetto delle disposizioni normative.

In riferimento ai punti su elencati, si conferma che gli aerogeneratori, comprensivi di tutti gli impianti ad essi collegati, rispondono alle disposizioni normative CE.

In merito alla sicurezza, l'efficienza iniziale dell'impianto, nonché l'eventuale non disponibilità di parti di ricambio durante la realizzazione del Parco, sarà predisposto apposito contratto secondo cui sarà cura del fornitore (Vestas) il montaggio e/o posa in opera, la messa in sicurezza, il collaudo e tutta l'ordinaria e straordinaria manutenzione dell'impianto.

B.1.c. Manuale D'uso Di Tutti I Componenti Dell'impianto

- Individuazione e descrizione delle modalità di corretto funzionamento dei componenti e delle operazioni manutentive che non richiedono competenze specialistiche (verifiche, pulizie, regolazioni, ecc…);
- Individuazione dei principali sintomi indicatori di anomalie e guasti, imminenti o in atto.

Il funzionamento degli aerogeneratori è regolato da un sistema di pitch control (sistema di controllo dell'angolo d'attacco pala) indipendente su ciascuna pala e con un sistema di controllo d'imbardata.

Il sistema di controllo consente all'aerogeneratore di lavorare a velocità del vento variabili, massimizzando la potenza generata in ogni momento e minimizzando le sollecitazioni e il rumore.

Il funzionamento degli aerogeneratori è regolato da un sistema di pitch control (sistema di controllo dell'angolo d'attacco pala) indipendente su ciascuna pala e con un sistema di controllo d'imbardata. Il sistema di controllo consente all'aerogeneratore di lavorare a velocità del vento variabili, massimizzando la potenza generata in ogni momento e minimizzando le sollecitazioni e il rumore.

Per chiarezza espositiva si riporta, in allegato, (allegato n.1 "General Specification V112-3.0 50/60 Hz) una descrizione dettagliata dell'aerogeneratore VESTAS V112-3.0 MW 50/60 Hz.

B.1.d. Manuale di manutenzione dell'impianto

- *Individuazione, descrizione dettagliata ed istruzioni operative degli interventi di manutenzione ordinarie e straordinaria per ogni componente dell'impianto;*
- *Descrizione delle risorse necessarie per l'intervento manutentivo di manutenzione; le istruzioni operative dettagliate per la manutenzione, che deve eseguire il tecnico.*

Per chiarezza espositiva si riporta, in allegato, (allegato n.2 "Check Mechanical and Electrical Part") una descrizione dettagliata dell'aerogeneratore VESTAS V112-3.0 MW 50/60 Hz e delle operazioni di gestione e manutenzione dello stesso fornita direttamente dalla casa produttrice dell'aerogeneratore.

B.1.E. PROGRAMMA DI MANUTENZIONE

- *Individuazione e descrizione dettagliata del sistema dei controlli e degli interventi da eseguire al fine di una corretta conservazione e gestione dell'impianto nella sua totalità e nelle sue parti;*
- *Individuazione e descrizione dettagliata delle scadenze temporali per tutte le operazioni di manutenzione;*

Si allegano (allegato n.2 "Check Mechanical and Electrical Part") le schede di manutenzione di ciascun componente della turbina eolica che riportano l'insieme delle operazioni da eseguire per assicurare il corretto funzionamento dell'aerogeneratore durante la sua vita utile.

- *Definizione dei fabbisogni di manodopera (specializzata e non) e delle altre risorse necessarie.*

Per eseguire le operazioni di cui sopra è indispensabile un tecnico specializzato, con patentino per lavori in alta quota e che abbia formazione specifica nel campo. Solo per specifiche operazioni sarà necessaria la presenza di un secondo manovale.
Si precisa, infine, che per la manodopera specializzata necessaria ad eseguire le su esposte fasi di manutenzione sarà effettuato regolare contratto direttamente con il fornitore degli aerogeneratori.

Class 1
Document no.: 0011-9181 V02
2010-09-22

General Specification

V112–3.0 MW 50/60 Hz

Table of Contents

Buyer acknowledges that these general specifications are for buyer's informational purposes only, do not constitute an offer for sale and do not create or constitute a warranty, guarantee, promise, commitment, or other representation by supplier, all of which are disclaimed by supplier except to the extent expressly provided by supplier in writing elsewhere.

Refer to section 11 General Reservations, Notes and Disclaimers, p. 31 for general reservations, notes, and disclaimers applicable to these general specifications.

1 General Description

The Vestas V112-3.0 MW wind turbine is a three-bladed pitch regulated upwind turbine with active yaw. The Vestas V112-3.0 MW turbine has a rotor diameter of 112 m and a rated output power of 3.075 MW. The turbine utilizes the OptiTip® and Grid Streamer™; concepts. With these features the wind turbine is able to operate the rotor at variable speed, and thereby maintaining the power output at or near rated power even in high wind speeds. At low wind speeds, the OptiTip® and Grid Streamer™ systems work together to maximize the power output by operating at the optimal rotor speed and pitch angle,.

2 Mechanical Design

2.1 Rotor

The V112-3.0 MW is equipped with a 112 meter rotor consisting of three blades and a hub. The blades are controlled by a microprocessor pitch control system called OptiTip®. Based on the prevailing wind conditions, the blades are continuously positioned to optimise the pitch angle.

Rotor	
Diameter	112 m
Swept Area	9852 m^2
Rotational Speed Static, Rotor	12.8 rpm
Speed, Dynamic Operation Range	6.2 – 17.7
Rotational Direction	Clockwise (front view)
Orientation	Upwind
Tilt	6°
Blade Coning	4°
Number of Blades	3
Aerodynamic Brakes	Full feathering

Table 2-1: Rotor data.

2.2 Blades

The blades are made of carbon and fibre glass and consist of two airfoil shells bonded to a supporting beam.

Blades	
Type Description	Airfoil shells bonded to supporting beam
Blade Length	54.65 m
Material	Fibre glass reinforced epoxy and carbon fibres
Blade Connection	Steel roots inserted
Air Foils	High-lift profile
Largest Chord	4.0 m

Table 2-2: Blades data.

2.3 Blade Bearing

The blade bearings are double row 4 point contact ball bearings.

Blade Bearing	
Lubrication	Grease, automatic lubrication pump

Table 2-3: Blade bearing data.

2.4 Pitch System

The turbine is equipped with a pitch system for each blade and a distributor block, all located in the hub. Each pitch system is connected to the distributor block with flexible hoses. The distributor block is connected to the pipes of the hydraulic rotating transfer unit in the hub by means of three hoses (pressure line, return line and drain line).

Each pitch system consists of a hydraulic cylinder mounted to the hub and with the piston rod mounted to the blade via a torque arm shaft. Valves facilitating operation of the pitch cylinder are installed on a pitch block bolted directly onto the cylinder.

Pitch System	
Type	Hydraulic
Number	1 per blade
Range	-9º to 90º

Table 2-4: Pitch system data.

Hydraulic System	
Main Pump	Two redundant internal gear oil pumps
Pressure	260 bar
Filtration	3 µm (absolute)

Table 2-5: Hydraulic system data.

2.5 Hub

The hub supports the three blades and transfers the reaction forces to the main bearing and torque to the gearbox. The hub structure also supports blade bearings and pitch cylinder.

Hub	
Type	Cast ball shell hub
Material	Cast iron

Table 2-6: Hub data.

2.6 Main Shaft

The main shaft transfers the reaction forces to the main bearing and the torque to the gearbox.

Main Shaft	
Type Description	Hollow shaft
Material	Cast iron

Table 2-7: Main shaft data.

2.7 Main Bearing House

The main bearing house covers the main bearing and is the first connection point for the drive train system to the base frame

Main Bearing	
Material	Cast iron

Table 2-8: Main bearing house data.

2.8 Main Bearing

The main bearing carries all thrust loads.

Main Bearing	
Type Description	Double row spherical roller bearing
Lubrication	Automatic grease lubrication

Table 2-9: Main bearing data.

2.9 Gearbox

The main gear converts the low-speed rotation of the rotor to high-speed generator rotation.

The gearbox is a four stage differential gearbox where the first 3 stages are planetary stages and the 4th is a helical stage.

The disc brake is mounted on the high speed shaft. The gearbox lubrication system is a pressure-fed system.

Gearbox	
Type Description	Differential, 3 planetary stage + 1 helical stage
Gear House Material	Cast
Ratio	1:113,2
Mechanical Power	3300 kW
Lubrication System	Pressure oil lubrication
Backup Lubrication System	Oil sump filled from external gravity tank
Total Gear Oil Volumen	App. 1170 l
Oil Cleanliness Codes	ISO 4406-/15/12
Shaft Seals	Labyrinth

Table 2-10: Gearbox data.

2.10 Generator Bearings

The bearings are grease lubricated and grease is supplied continuously from an automatic lubrication unit.

2.11 High Speed Shaft Coupling

The coupling transmits the torque of the gearbox high speed output shaft to the generator input shaft.

The coupling consists of two 4 link laminate packages and a fibre glass intermediate tube with two metal flanges. The coupling is fitted to 2-armed hubs on the brake disc and the generator hub.

2.12 Yaw System

The yaw system is an active system based on a robust pretensioned plain yaw bearing concept with PETP as friction material.

The yaw gears are 2-stage planetary gears with a worm drive and with built in torque limiters

The worm drive is self locking to prevent unintentional yawing.

Yaw System	
Type	Plain bearing system with built-in friction
Material	Forged yaw ring heat-treated. Plain bearings PETP
Yawing Speed 50 Hz	0.5˚/sec.
Yawing Speed 60 Hz	0.6˚/sec.

Table 2-11: Yaw system data.

Yaw Gear	
Type	2-step planetary gear with worm drive
Number of Yaw Gears	8
Ratio Total (4 Planetary Stages)	944 : 1
Rotational Speed at Full Load	1.4 rpm at output shaft

Table 2-12: Yaw gear data.

2.13 Crane

The nacelle houses the internal Safe Working Load (SWL) service crane. The crane is a single system chain hoist.

Crane	
Lifting Capacity	Max. 990 kg
Power supply	3 x 400 V, 10 A

Table 2-13: Crane data.

2.14 Towers

Tubular towers with flange connections, certified according to relevant type approvals, are available in different standard heights. The towers are designed with the majority of internal welded connections replaced by magnet supports to create a predominantly smooth-walled tower. Magnets provide load support in a horizontal direction and internals, such as platforms, ladders, etc., are supported vertically (i.e. in the gravitational direction) by a mechanical connection. The smooth tower design reduces the required steel thickness, rendering the tower lighter compared one with internals solely welded to the tower shells.

The hub heights listed include a distance from the foundation section to the ground level of approximately 0.2 m depending on the thickness of the bottom flange and a distance from the tower top flange to the centre of the hub of 2.2 m.

Towers	
Type Description	Cylindrical/Conical tubular
Hub Heights	84 m/94 m/119 m
Maximum Diameter	4.2 m (Standard)/4.45 m (119 m DIBt 2))
Material	Steel

Table 2-14: Tower structure data.

2.15 Nacelle Base-Frame and Cover

The nacelle cover is made of fibreglass. Hatches are positioned in the floor for lowering or hoisting equipment to the nacelle and evacuation of personnel. The roof section is equipped with wind sensors and skylights. The skylights can both be opened from inside the nacelle to access the roof and from outside to access the nacelle. Access from the tower to the nacelle is through the yaw System.

The nacelle bedplate is in two parts and consists of a cast iron front part and a girder structure rear part. The front of the nacelle bedplate is the foundation for the drive train, which transmits forces from the rotor to the tower, through the yaw system. The bottom surface is machined and connected to the yaw bearing and the eight yaw-gears are bolted to the front nacelle bedplate.

The crane beams are attached to the top structure. The lower beams of the girder structure are connected at the rear end. The rear part of the bedplate serves as the foundation for controller panels, cooling system and transformer. The nacelle cover is mounted on the nacelle bedplate.

Type Description	Material
Nacelle Cover	GRP
Base Frame Front	Cast iron
Base Frame Rear	Girder Structure

Table 2-15: Nacelle base-frame and cover data.

2.16 Thermal Conditioning System

The thermal conditioning system consists of a few and robust components:

- The Vestas Cooler Top™ located on top of the rear end of the nacelle. The cooler top is a free flow cooler thus ensuring that there are no electrical components in the thermal conditioning system located outside the nacelle.
- Liquid cooling system I, which serves the gearbox and hydraulic systems and is driven by a single electrical pump.
- Liquid cooling system II, which serves the generator and converter systems and is driven by a single electrical pump.
- The transformer forced air cooling comprising an electrical fan.
- The nacelle forced air cooling comprising two electrical fans.

2.16.1 Generator- and Converter Cooling

The generator and converter cooling systems operate in parallel. A dynamic flow valve mounted in the generator cooling circuit divides the cooling flow. The cooling liquid removes heat from the generator and converter unit through a free air flow radiator placed at the top of the nacelle. In addition to the generator, converter unit and radiator, the circulation system includes an electrical pump and a 3-way thermostatic valve.

2.16.2 Gearbox- and Hydraulic Cooling

The gearbox and hydraulic cooling systems are coupled in parallel. A dynamic flow valve mounted in the gearbox cooling circuit divides the cooling flow. The cooling liquid removes heat from the gearbox and the hydraulic power unit through heat exchangers and a free air flow radiator placed at the top of the nacelle. In addition to the heat exchangers and the radiator, the circulation system includes an electrical pump and a 3-way thermostatic valve.

2.16.3 Transformer Cooling

The transformer is equipped with forced air cooling. The ventilator system consists of a central fan, located below the service floor and an air duct leading the air to locations beneath and between the HV and LV windings of the transformer.

2.16.4 Nacelle Cooling

Hot air generated by mechanical and electrical equipment is removed from the nacelle by two fans located at each side of the nacelle. The airflow enters the nacelle through an air intake in the bottom of the nacelle. The fans can run at low or high speed depending on the temperature in the nacelle.

3 Electrical Design

3.1 Generator

The generator is a 3-phase synchronous generator with a permanent magnet rotor which is connected to the grid through the Grid Streamer™ full scale converter.

The generator housing is built with a cylindrical jacket and channels, which circulate cooling liquid around the generator internal stator housing.

Generator	
Type Description	Synchronous with permanent magnets
Rated Power [P_N]	3.3 MW
Rated Apparent Power [S_N]	3880 kVA (Cosφ = 0.85)
Frequency [f_N]	145 Hz
Voltage, Stator [U_{NS}]	3 x 710 V (@ 1450 RPM)
Number of Poles	12
Winding Type	Form with VPI (Vacuum Pressurized Impregnation)
Winding Connection	Star
Rated Efficiency (Generator only)	98 %
Rated RPM / Rated Slip	1450 RPM
Over Speed Limit acc. to IEC (2 min.)	2400 RPM
Vibration Level	≤ 1.8 mm/s
Generator Bearing	Hybrid/Ceramic
Temperature sensors, Stator	3 Pt100 sensors placed at hot spots and 3 as back-up
Temperature sensors, Bearings	1 per bearing and 1 back-up per bearing
Insulation Class	H (3 kV)
Enclosure	IP54

Table 3-1: Generator data.

3.2 Converter

The Grid Streamer™ converter is a full scale converter system controlling both the generator and the power quality delivered to the grid.

The converter consists of four converter units operating in parallel with a common controller.

The converter controls conversion of variable frequency power from the generator into fixed frequency AC power having desired active and reactive power levels (and other grid connection parameters) suitable for the grid. The converter is located in the nacelle and has a grid side voltage rating of 650 V. The generator side voltage rating is up to 710 V dependent on generator speed.

Converter	
Rated Apparent Power [S_N]	3800 kVA
Rated Grid Voltage	650 V
Rated Generator Voltage	710 V
Rated Current	3440 A

Table 3-2: Converter data.

3.3 HV Transformer

The step-up transformer is located in a separate locked room in the nacelle with surge arresters mounted on the high voltage side of the transformer. The transformer is a two winding, three-phase dry-type transformer, which is self-extinguishing. The windings are delta-connected on the high voltage side unless otherwise specified.

The low voltage winding is star-connected. The low voltage system from the generator via the converters is a TN-S system, which means the star point is connected to earth.

The transformer is equipped with 6 PT100 temperature sensors for measuring of core and winding temperatures in the 3 phases.

The nacelle auxiliary power supply is supplied from a separate 650/400 V transformer located in the nacelle.

HV Transformer	
Type Description	Dry-type cast resin
Primary Voltage [U_N]	10-35 kV
Secondary Voltage [U_{NS}]	3 x 650 V
Rated Apparent Power [S_N]	3450 kVA
No Load Loss [P_0]	6.6 kW
Load Losses (@ 120° C) [P_n]	24.5 kW
No Load Reactive Power [Q_0]	7.5 kVAr
Full Load Reactive Power [Q_n]	275 kVAr
Vector Group	Dyn5 (options: YNyn0)

HV Transformer	
Frequency	50/60 Hz
HV-tappings	± 2 x 2.5 % offload
Inrush Current	6-10 x $\hat{I}_n$ depending on type.
Short-Circuit Impedance	8% @ 650 V, 3450 kVA, 120°C
Positive Sequence Short Circuit Impedance Voltage $U_{k\ p\text{-}s1}$	7.95 %
Positive Sequence Short Circuit Impedance Voltage (Resistive) $U_{kr\ p\text{-}s1}$	0.72 %
Zero Sequence Short Circuit Impedance Voltage $U_{k0\ p\text{-}s1}$	7.55 %
Zero Sequence Short Circuit Impedance Voltage (Resistive) $U_{kr0\ p\text{-}s1}$	0.72 %
Insulation Class	F
Climate Class	C2
Environmental Class	E2
Fire Behaviour Class	F1

Table 3-3: Transformer data.

3.4 HV Cables

The high voltage cable runs from the transformer in the nacelle down the tower to the switchgear located at the bottom of the tower. The high voltage cable is a 4-core rubber insulated halogen free high voltage cable.

HV Cables	
High Voltage Cable Insulation Compound	Improved ethylene-propylene (EP) based material – EPR or high modulus or hard grade ethylene-propylene rubber – HEPR
Conductor Cross Section	3x70/70 mm^2
Max Voltage	24 kV / 42 kV depending on the rated transformer voltage

Table 3-4: HV cables data.

3.5 HV Switchgear

The high voltage switchgear is located in the bottom of the tower.

HV switchgear			
Type	Gas insulated SF6		
Nominal frequency	50/60 Hz		
Nominal rated voltage	10 – 22 kV	22.1 – 33 kV	33.1 – 35 kV
Max voltage	24 kV	36 kV	40.5 kV

HV switchgear			
Max short circuit current 1 sec	20 kA	25 kA	25 kA

Table 3-5: HV switchgear data.

3.6 AUX System

The AUX System is supplied from the separate 650/400 V transformer. All motors, pumps, fans and heaters are supplied from this system.

All 230 V consumers are supplied from a 400/230 V transformer.

Power Sockets	
Single Phase (Nacelle & Tower platforms)	230 V (16 A)/110 V (16 A)/2x55 V (16 A)
Three Phase (Nacelle & Tower base)	3 x 400 V (16 A)

Table 3-6: AUX system data.

3.7 Wind Sensors

The turbine is equipped with two ultrasonic wind sensors with no movable parts.

The sensors have built in heaters to minimize interference from ice/snow.

The wind sensors are redundant, and the turbine is able to operate with one sensor only.

Wind Sensors	
Type	FT702LT
Principle	Acoustic Resonance
Built in Heat	99 W

Table 3-7: Wind sensor data.

3.8 VMP (Vestas Multi Processor) Controller

The turbine is controlled and monitored by the VMP6000 control system.

VMP6000 is a multiprocessor control system comprised of four main processors (Ground, Nacelle, Hub and Converter) interconnected by an optical-based 2.5 Mbit ArcNet network.

In addition to the four main processors the VMP6000 consists of a number of distributed I/O modules interconnected by a 500 kbit CAN network

I/O modules are connected to CAN interface modules by a serial digital bus, CTBus.

The VMP6000 controller serves the following main functions:

- Monitoring and supervision of overall operation.
- Synchronizing of the generator to the grid during connection sequence.
- Operating the wind turbine during various fault situations.
- Automatic yawing of the nacelle.
- OptiTip® - blade pitch control.
- Reactive power control and variable speed operation.

- Noise emission control.
- Monitoring of ambient conditions.
- Monitoring of the grid.
- Monitoring of the smoke detection system.

3.9 Uninterruptible Power Supply (UPS)

The UPS is equipped with an AC/DC DC/AC converter (double conversions) and battery cells placed in the same cabinet as the converter. During grid outage, the UPS will supply specific components with 230V AC.

The back-up time for the UPS system is proportional to the power consumption. Actual back-up time may vary.

UPS		
Battery Type	Valve-Regulated Lead Acid (VRLA)	
Rated Battery Voltage	2 x 8 x 12 V (192 V)	
Converter Type	Double conversion	
Converter Input	230 V +/-20%	
Rated Output Voltage	230 V AC	
Back-up Time*	Controller system	15 minutes
	Switchgear function (motor release/activation)	15 minutes
	Remote control system	15 minutes
	Internal light in tower and nacelle	1 hour (supplied by built in batteries)
	Aviation light	1 hour
Re-charging Time	80%	App. 3 hours
	100%	App. 8 hours

Table 3-8: UPS data.

NOTE * For alternative back-up times, consult Vestas.

4 Turbine Protection Systems

4.1 Braking Concept

The main brake on the turbine is aerodynamic. Braking the turbine is done by full feathering the three blades (individual turning of each blade). Each blade has a hydraulic accumulator as power supply for turning the blade. Braking of the turbine is furthermore supported by a breaking resistor, which is connected to the permanent magnet generator during shut down. Thereby loss of torque is prevented in e.g. grid loss situations.

In addition there is a mechanical disc brake on the high speed shaft of the gearbox with a dedicated hydraulic system. The mechanical brake is only used as a parking brake, and when activating the emergency stop push buttons.

4.2 Short Circuit Protections

Breakers	Breaker for Aux. Power. T4L 250A TMD 4P 690 V	Breaker for Converter Modules T7M1200L PR332/P LSIG 1000 A 3P 690 V
Breaking Capacity, I_{cu}, I_{cs}	70 kA @ 690 V	50 kA @ 690 V
Making Capacity, I_{cm}	154 kA @ 690 V	105 kA @ 690 V
L, Overload - **Timedelay t_1**	175 – 250 A K	480 - 1200 A 3 -144 sec
S, Short Circuit - **Timedelay t_2**	N/A N/A	0.72 – 12 kA 0.1 – 0.8 sec
I, Short Circuit - **Instantaneous t_3**	1.25 – 2.5 kA K	1.8 – 18 kA K
G, Earth Fault - **Timedelay t_4**	N/A N/A	240 - 1200 A 0.1 – 0.8 sec

Table 4-1: Short circuit protection data.

The table below shows HV switchgear settings and how full load phase current on HV switchgear depend on actual line voltage. Note: Minimum line voltage $\mathbf{U_{N,min}}$ is defined as nominal line voltage $\mathbf{U_N}$ minus allowed continuous undervoltage (e.g. 10 %).

HV Switchgear Settings	
Full Load Phase Current, I_N [A]	$S_{N,trafo}$ /($U_{N,min}$ * √3)
Phase Overload Factor	1.1
Phase Multiplier Constant (Scale Factor)	0.1
Instantaneous Phase Multiplier	Min. 8
Instantaneous Phase to Phase Time Setting, [sec]	0.1
Ground Leak Factor	0.1
Zero Sequence Multiplier Constant	0.05
Instantaneous Zero Sequence Multiplier	2
Instantaneous Zero Sequence Time Setting, [sec]	0.1

Table 4-2: HV switchgear settings.

4.3 Overspeed Protection

The generator RPM and the main shaft RPM are registered by inductive sensors and calculated by the wind turbine controller in order to protect against over-speed and rotating errors.

In addition, the turbine is equipped with a Safety PLC, which is an independent computer module measuring the rotor RPM, and in case of an overspeed situation the Safety PLC activates the emergency feathered position (full feathering) of the three blades independently of the turbine controller in the turbine.

Overspeed Protection	
Sensors Type	Inductive

Overspeed Protection	
Trip Levels	17.66 (Rotor RPM)/2000 (Generator RPM)

Table 4-3: Overspeed protection data.

4.4 Lightning Protection of Blades, Nacelle, Hub & Tower

The Lightning Protection System (LPS) helps protect the wind turbine against the physical damage caused by lightning strikes. The LPS consists of five main parts.

- Lightning receptors.
- Down conducting system. A system to conduct the lightning current down through the wind turbine to help avoid or minimise damage to the LPS system itself or other parts of the wind turbine.
- Protection against over-voltage and over-current.
- Shielding against magnetic and electrical fields.
- Earthing System.

Lightning Protection Design Parameters			**Protection Level I**
Current Peak Value	i_{max}	[kA]	200
Impulse Charge	$Q_{impulse}$	[C]	100
Long Duration Charge	Q_{long}	[C]	200
Total Charge	Q_{total}	[C]	300
Specific Energy	W/R	[MJ/Ω]	10
Average Steepness	di/dt	[kA/μs]	200

Table 4-4: Lightning protection design parameters.

NOTE Lightning strikes are considered force majeure, i.e. damage caused by lightning strikes is not warranted by Vestas.

4.5 Earthing

The Vestas Earthing System consists of a number of individual earthing electrodes interconnected as one joint earthing system.

The Vestas Earthing System includes the TN-system and the lightning protection system for each wind turbine. It works as an earthing system for the medium voltage distribution system within the wind power plant.

The Vestas Earthing System is adapted to the different types of foundation a turbine can be erected on. A separate set of documents describe the Earthing System in detail, depending on the type of foundation the turbine is erected on.

In terms of lightning protection of the wind turbine, Vestas has no separate requirements for a certain minimum resistance to remote earth (measured in ohms) for this system. The earthing for the lightning protection system is based on the design and construction of the Vestas Earthing System.

A part of the Vestas Earthing System is the main earth bonding bar placed where all cables enter the wind turbine. All earthing electrodes are connected to this main earth bonding bar. Additionally, equipotential connections are made to all cables entering or leaving the wind turbine.

Requirements in the Vestas Earthing System specifications and work descriptions are minimum requirements from Vestas and IEC. Local and national requirements, as well as project requirements, may require additional measures.

4.6 Corrosion Protection

Classification of corrosion protection is according to ISO 12944-2.

Corrosion Protection	External Areas	Internal Areas
Nacelle	C5	C3 and C4 Climate Strategy: Heating the air inside the nacelle compared to the outside air temperature lowers the relative humidity and helps ensure a controlled corrosion level.
Hub	C5	C3
Tower	C5-I	C3

Table 4-5: Corrosion protection data for nacelle, hub and tower.

5 Safety

The safety specifications in Section 5 provide limited general information about the safety features of the turbine and are not a substitute for Buyer and its agents taking all appropriate safety precautions, including but not limited to (a) complying with all applicable safety, operation, maintenance, and service agreements, instructions, and requirements, (b) complying with all safety-related laws, regulations, and ordinances, and (c) conducting all appropriate safety training and education.

5.1 Access

Access to the turbine from the outside is through the bottom of the tower. The door is equipped with a lock. Access to the top platform in the tower is by a ladder or service lift. Access to the nacelle from the top platform is by ladder. Access to the transformer room in the nacelle is equipped with a lock. Unauthorized access to electrical switch boards and power panels in the turbine is prevented according to IEC 60204-1 2006.

5.2 Escape

In addition to the normal access routes, alternative escape routes from the nacelle are through the crane hatch, from the spinner by opening the nose cone, or from the roof of the nacelle. Rescue equipment is placed in the nacelle.

The hatch in the roof can be opened from both the inside and outside.

Escape from the service lift is by ladder.

An emergency response plan placed in the turbine describes evacuation and escape routes.

5.3 Rooms/Working Areas

The tower and nacelle are equipped with power sockets for electrical tools for service and maintenance of the turbine.

5.4 Floors, Platforms, Standing-, Working Places

All floors have anti-slip surfaces.

There is one floor per tower section.

Rest platforms are provided at intervals of 9 metres along the tower ladder between platforms.

Foot supports are placed in the turbine for maintenance and service purposes.

5.5 Climbing Facilities

A ladder with a fall arrest system (rigid rail) is mounted through the tower.

There are anchorage points in the tower, nacelle, hub, and on the roof for attaching fall arrest equipment (full body harness).

Over the crane hatch there is an anchorage point for the emergency descent equipment.

Anchorage points are coloured yellow and are calculated and tested to 22.2 kN.

5.6 Moving Parts, Guards and Blocking Devices

All moving parts in the nacelle are shielded.

The turbine is equipped with a rotor lock to block the rotor and drive train.

Blocking the pitch of the cylinder can be done with mechanical tools in the hub.

5.7 Lights

The turbine is equipped with light in the tower, nacelle, transformer room and in the hub.

There is emergency light in case of loss of electrical power.

5.8 Emergency Stop

There are emergency stop push buttons in the nacelle, hub and in the bottom of the tower.

5.9 Power Disconnection

The turbine is equipped with breakers to allow for disconnection from all its power sources during inspection or maintenance. The switches are marked with signs and are located in the nacelle and in the bottom of the tower.

5.10 Fire Protection/First Aid

A handheld 5-6 kg CO_2 fire extinguisher, first aid kit and fire blanket are located in the nacelle during service and maintenance.

5.11 Warning Signs

Warning signs placed inside or on the turbine must be reviewed before operating or servicing the turbine.

5.12 Manuals and Warnings

Vestas OH&S manual and manuals for operation, maintenance and service of the turbine provide additional safety rules and information for operating, servicing or maintaining the turbine.

6 Environment

6.1 Chemicals

Chemicals used in the turbine are evaluated according to Vestas Wind Systems A/S environmental system certified according to ISO 14001:2004. The following chemicals are used in the turbine:

- Cooling liquid to help prevent the cooling system from freezing.
- Gear oil for lubricating the gearbox.
- Hydraulic oil to pitch the blades and operate the brake.
- Grease to lubricate bearings.
- Various cleaning agents and chemicals for maintenance of the turbine.

7 Approvals and Design Codes

7.1 Type Approvals

The turbine is type certified according to the certification standards listed below:

Standard	Conditions	Hub Height
IEC61400-22	IEC Class IIA	84 m / 94 m
	IEC Class IIIA	119 m
DIBt Anlage 2.7/10	DIBt 2	94 m / 119 m
UL 6140 (Construction Only)	60 Hz Variant Only	NA

Table 7-1: Type approvals data.

7.2 Design Codes – Structural Design

The structural design has been developed and tested with regard to, but not limited to, the following main standards:

Design Codes - Structural Design	
Nacelle and Hub	IEC 61400-1 Edition 3 EN 50308
Tower	IEC 61400-1 Edition 3 Eurocode 3
Blades	DNV-OS-J102 IEC 1024-1 IEC 60721-2-4 IEC 61400 (Part 1, 12 and 23) IEC WT 01 IEC DEFU R25 ISO 2813 DS/EN ISO 12944-2

Table 7-2: Structural design codes.

7.3 Design Codes – Lightning Protection

The lightning protection system is designed according to Lightning Protection Level (LPL) I:

Design Codes – Lightning Protection	
Designed according to	IEC 62305-1: 2006 IEC 62305-3: 2006 IEC 62305-4: 2006
Non Harmonized Standard and Technically Normative Documents	IEC/TR 61400-24:2002

Table 7-3: Lightning protection design codes.

8 Colours

8.1 Nacelle Colour

Colour of Vestas Nacelles	
Standard Nacelle Colour	RAL 7035 (light grey)
Standard Logo	Vestas

Table 8-1: Colour, nacelle.

8.2 Tower Colour

Colour of Vestas Tower Section		
	External:	**Internal:**
Standard Tower Colour	RAL 7035 (light grey)	RAL 9001 (cream white)

Table 8-2: Colour, tower.

8.3 Blades Colour

Blades Colour	
Standard Blade Colour	RAL 7035 (Light Grey)
Tip-End Colour Variants	RAL 2009 (Traffic Orange), RAL 3020 (Traffic Red)
Gloss	< 30% DS/EN ISO 2813

Table 8-3: Colour, blades.

9 Operational Envelope and Performance Guidelines

Actual climatic and site conditions have many variables and should be considered in evaluating actual turbine performance. The design and operating parameters set forth in this section do not constitute warranties, guarantees, or representations as to turbine performance at actual sites.

9.1 Climate and Site Conditions

Values refer to hub height:

Extreme Design Parameters	
	IEC IIA
Ambient Temperature Interval (Normal Temperature Turbine)	-40° to +50° C
Extreme Wind Speed (10 min. average)	42.5 m/s
Survival Wind Speed (3 sec. gust)	59.5 m/s

Table 9-1: Extreme design parameters.

Average Design Parameters	
Wind Climate	**IEC IIA**
Wind Speed	8.5 m/s
A-factor	9.59 m/s
Form Factor, c	2.0
Turbulence Intensity acc. to IEC 61400-1, including Wind Farm Turbulence (@15 m/s – 90% quantile)	18%
Wind Shear	0.20
Inflow Angle (vertical)	8°

Table 9-2: Average design parameters.

9.1.1 Complex Terrain

Classification of complex terrain acc. to IEC 61400-1:2005 Chapter 11.2.

For sites classified as complex appropriate measures are to be included in site assessment.

Positioning of each turbine must be verified via the Vestas Site Check program.

9.1.2 Altitude

The turbine is designed for use at altitudes up to 1500 m above sea level as standard.

Above 1500 m special considerations must be taken regarding e.g. HV installations and cooling performance. Consult Vestas for further information.

9.1.3 Wind Power Plant Layout

Turbine spacing shall be evaluated site-specifically. Spacing in any case not below three rotor diameters (3D).

NOTE As evaluation of climate and site conditions is complex it is recommended to consult Vestas for every project. If conditions exceed the above parameters Vestas has to be consulted.

9.2 Operational Envelope – Temperature and Wind

Values are as determined by the sensors and control system of the turbine at hub height.

Operational Envelope – Temperature and Wind	
Ambient Temperature Interval (Normal Temperature Turbine)	-20° to +40° C
Cut-in (10 min. average)	3 m/s
Cut-out (10 min. average)	25 m/s
Re-cut in (10 min. average)	23 m/s

Table 9-3: Operational envelope – temperature and wind.

9.3 Operational Envelope – Grid Connection

Values are determined by the sensors and control system of the turbine.

Operational Envelope – Grid Connection		
Nominal Phase Voltage	[U_{NP}]	650 V
Nominal Frequency	[f_N]	50/60 Hz
Max. Steady State Voltage Jump	+/- 2 % (from turbine) +/- 4 % (from grid)	
Max. Frequency Gradient	+/- 4 Hz/sec	
Max. Negative Sequence Voltage	3 % (Connection) 2 % (Operation)	
Min. Short Circuit Level	15 MVA	

Table 9-4: Operational envelope – grid connection.

The generator and the converter will be disconnected if*:

Protection Settings	
Voltage above 110 % of Nominal for 60 sec.	715 V
Voltage above 115 % of Nominal for 2 sec.	748 V
Voltage above 120 % of Nominal for 0.08 sec.	780 V
Voltage above 125 % of Nominal for 0.005 sec.	812 V
Voltage below 90 % of Nominal for 60 sec.	585 V
Voltage below 85 % of Nominal for 11 sec.	552 V

Protection Settings	
Frequency is above 106 % of Nominal for 0.2 sec.	53/63.6 Hz
Frequency is below 94 % of Nominal for 0.2 sec.	47/56.4 Hz

Table 9-5: Protection settings – grid connection.

NOTE * Over the turbine lifetime, grid drop-outs are to occur at an average of no more than 20 times a year.

9.4 Operational Envelope – Reactive Power Capability

The turbine has a reactive power capability as illustrated in figure 9-1.

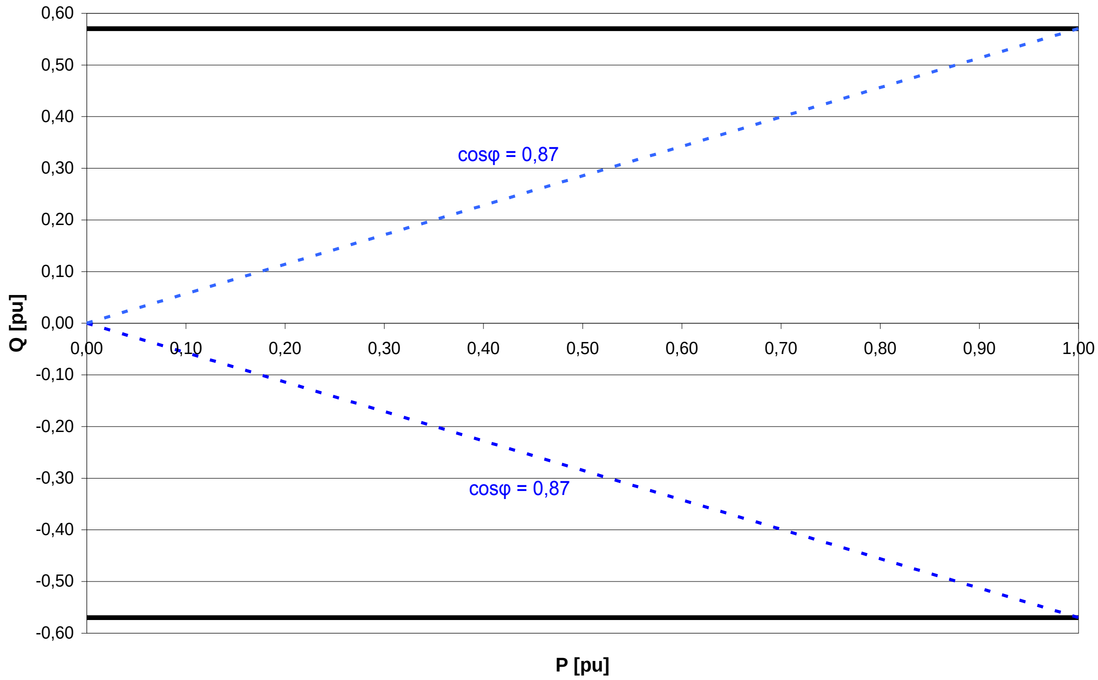


Figure 9-1: Reactive power capability

The above chart applies at the low voltage side of the HV transformer.

Reactive power capability at full load on high voltage side of the HV transformer is approx: cosφ = 0.90/0.83 capacitive/inductive.

Reactive power is produced by the Grid Streamer™ converter; therefore traditional capacitors are not used in the turbine.

NOTE The reactive power capability at no load operation may be reduced up to 50 % due to cooling system capacity constraints.

9.5 Performance – Fault Ride Through

The turbine is equipped with a Grid Streamer^{TM} converter in order to gain better control of the wind turbine during grid faults. The turbine control system continues to run during grid faults.

The turbine is designed to stay connected during grid disturbances within the voltage tolerance curve in Figure 9-2, p. 26.

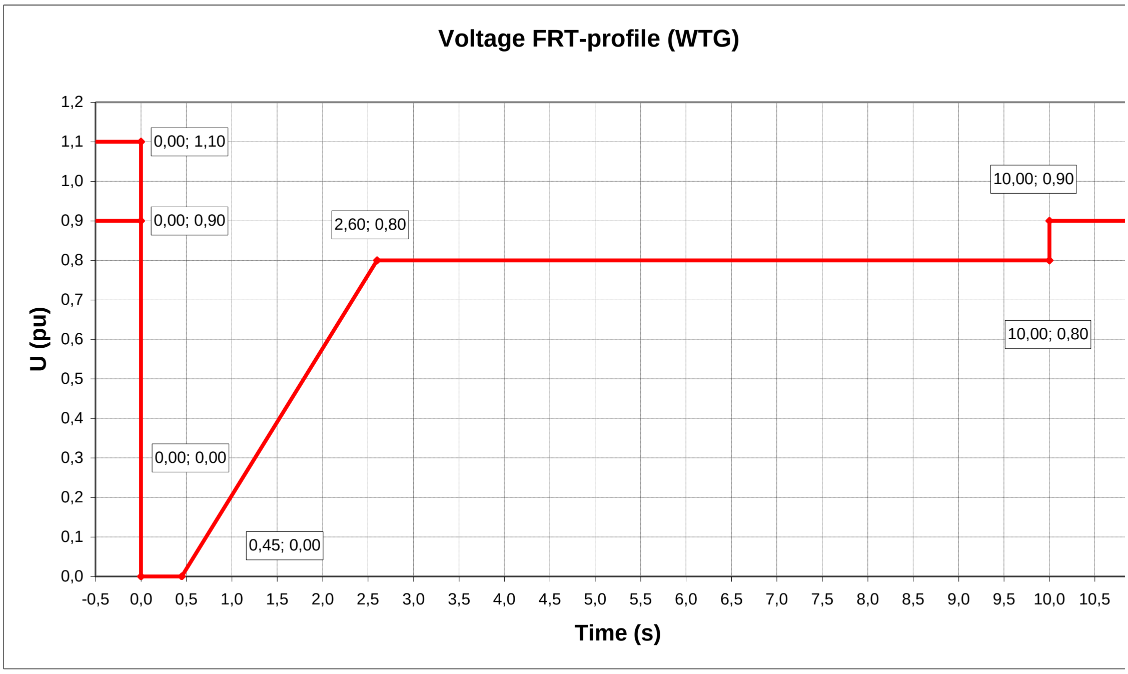


Figure 9-2: Low voltage tolerance curve for symmetrical and asymmetrical faults.

For grid disturbances outside the protection curve the turbine will be disconnected from the grid.

Power Recovery Time	
Power Recovery to 90% of Pre-fault Level	Max 0.1 s

Table 9-6: Power Recovery Time.

9.6 Performance – Reactive Current Contribution

The reactive current contribution depends on whether the fault applied to the turbine is symmetrical or asymmetrical.

9.6.1 Symmetrical Reactive Current Contribution

During symmetrical voltage dips the wind fpower plant will inject reactive current to support the grid voltage. The reactive current injected is a function of the measured grid voltage.

The default value gives a reactive current part of 1 pu of the rated wind power plant current at the point of common coupling. Figure 9-3 indicates the reactive current contribution as a function of the voltage. The reactive current contribution is independent from the actual wind conditions and pre-fault power level.

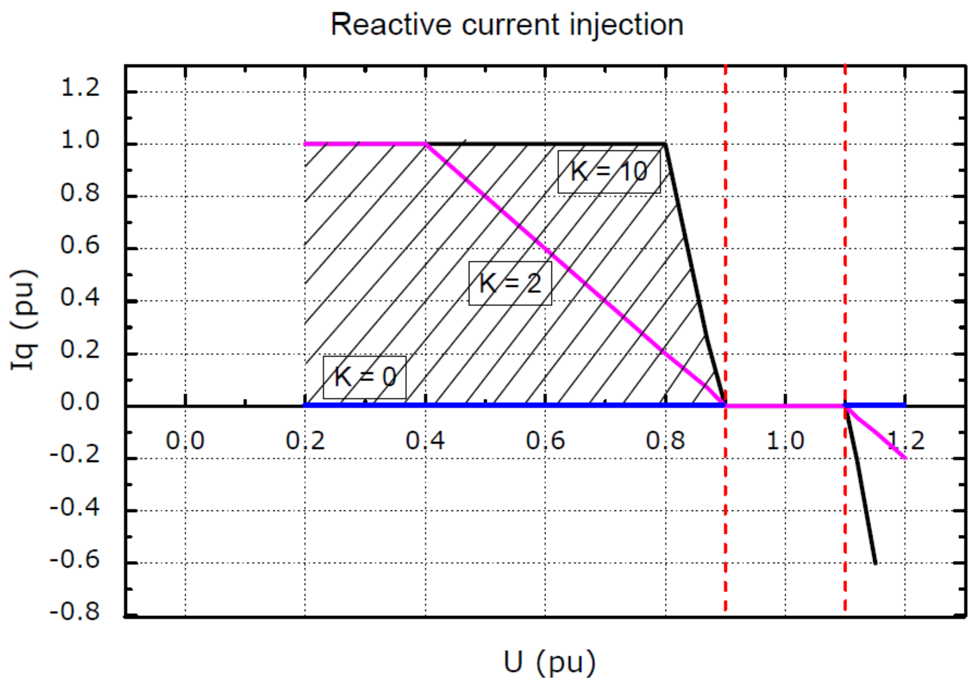


Figure 9-3: The default current injection slope is 2 % reactive current increase per 1 % voltage decrease. The slope can be parameterized between 2 and 10 to adapt to site specific requirements.

9.6.2 Asymmetrical Reactive Current Contribution

Current reference values are controlled for each phase and current injection follows the requirements for symmetrical current injection.

9.7 Performance – Multiple Voltage Dips

The turbine is designed to handle re-closure events and multiple voltage dips within a short period of time, due to the fact that voltage dips are not evenly distributed during the year. As an example the turbine is designed to perform at 10 voltage dips of duration of 200 ms down to 20% voltage within 30 minutes.

9.8 Performance – Active and Reactive Power Control

The turbine is designed for control of active and reactive power via the VestasOnline® SCADA system.

Max. Ramp Rates for External Control	
Active Power	0.1 pu/sec (300 kW/sec)
Reactive Power	20 pu/sec (60 MVAr/sec)

Table 9-7: Active/Reactive Power Ramp Rates.

To protect the turbine active power cannot be controlled to values below 20% of nominal power for any wind speed.

9.9 Performance – Voltage Control

The turbine is designed for integration with VestasOnline® voltage control by utilising the turbine reactive power capability.

9.10 Performance – Frequency Control

The turbine can be configured to perform frequency control by decreasing the output power as a linear function of the grid frequency (over frequency).

Deadband and slope for the frequency control function are configurable.

9.11 Own Consumption

The consumption of electrical power by the wind turbine is defined as the power used by the wind turbine when it is not providing energy to the grid. This is defined in the control system as Production Generator 0 (zero).The following components have the largest influence on the own consumption of the wind turbine (the average own consumption depends on the actual conditions, the climate, the wind turbine output, the cut-off hours etc.):

Own Consumption	
Hydraulic Motor	2x15 kW (master/slave)
Yaw Motors 8 x 2.2 kW	17.6 kW
Water Heating	10 kW
Water Pumps	2.2 + 5.5 kW
Oil Heating	7.9 kW
Oil Pump for Gearbox Lubrication	10 kW
Controller including Heating Elements for the Hydraulics and all Controllers	Max. app. 3 kW
HV Transformer No-load Loss	Max. 6.6 kW

Table 9-8: Own consumption data.

9.12 Operational Envelope – Conditions for Power Curve, Noise Levels, C_t Values (at Hub Height)

Consult Appendix in section 12 for power curves, C_t values, and noise levels.

Conditions for Power Curve, Noise Levels, C_t Values (at Hub Height)	
Wind Shear	0.10 - 0.16 (10 min. average)
Turbulence Intensity	8 - 12% (10 min. average)
Blades	Clean
Rain	No
Ice/Snow on Blades	No
Leading Edge	No damage
Terrain	IEC 61400-12-1
Inflow Angle (Vertical)	0 ± 2°
Grid Frequency	Nominal Frequency ± 0.5 Hz

Table 9-9: Conditions for power curve, C_t values, and noise levels.

10 Drawings

10.1 Structural Design – Illustration of Outer Dimensions

To be included in future version of the document

Figure 10-1: Illustration of outer dimensions – structure.

10.2 Structural Design – Side View Drawing

To be included in future version of the document

Figure 10-2: Side view drawing.

10.3 Structural Design – Centre of Gravity

To be included in future version of the document

Figure 10-3: Centre of gravity.

10.4 Structural Design – Tower Drawing (Example)

To be included in future version of the document

Figure 10-4: Tower design

NOTE Once the foundation is completed, the position of the tower door is fixed to ensure a safe position in relation to the electrical cabinets inside the tower.

10.5 Electrical Design – Main Wiring

To be included in future version of the document

Figure 10-5: Main wiring 50 Hz.

11 General Reservations, Notes and Disclaimers

- This General Specification applies to the current version of the V112-3.0 MW wind turbine. Updated versions of the V112-3.0 MW wind turbine, which may be manufactured in the future, may differ from this General Specification. In the event that Vestas supplies an updated version of the V112-3.0 MW wind turbine, Vestas will provide an updated General Specification applicable to the updated version.
- The 60 Hz variant will be available in USA spring 2011 and in Canada spring 2012.
- Periodic operational disturbances and generator power de-rating may be caused by combination of high winds, low voltage or high temperature.
- Vestas recommends that the grid be as close to nominal as possible with limited variation in frequency and voltage.
- A certain time allowance for turbine warm-up must be expected following grid dropout and/or periods of very low ambient temperature.
- All listed start/stop parameters (e. g. wind speeds and temperatures) are equipped with hysteresis control. This can, in certain borderline situations, result in turbine stops even though the ambient conditions are within the listed operation parameters.
- The earthing system must comply with the minimum requirements from Vestas, and be in accordance with local and national requirements, and codes of standards.
- Lightning strikes are considered force majeure, i.e. damage caused by lightning strikes is not warranted by Vestas.
- For the avoidance of doubt, this General Specification is not an offer for sale, and does not contain, any guarantee, warranty and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method). Any guarantee, warranty and/or verification of the power curve and noise (including, without limitation, the power curve and noise verification method) must be agreed to separately in writing.

12 Appendix

12.1 Mode 0

12.1.1 Power Curves

Wind speed [m/s]	Air density [kg/m^3]												
	Standard 1.225	0.95	0.975	1	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3	23	13	14	14	15	16	17	18	19	20	21	22	24	25
3.5	68	41	44	46	48	51	53	56	58	61	63	66	71	73
4	130	88	92	96	100	104	107	111	115	119	123	126	134	138
4.5	206	148	153	158	164	169	174	180	185	190	196	201	212	217
5	301	221	228	236	243	250	258	265	272	279	287	294	308	316
5.5	418	311	321	330	340	350	359	369	379	389	398	408	427	437
6	557	419	432	444	457	469	482	494	507	519	532	544	569	582
6.5	720	546	562	578	594	610	626	641	657	673	689	705	736	752
7	912	695	715	734	754	774	793	813	833	853	872	892	931	951
7.5	1130	865	889	913	938	962	986	1010	1034	1058	1082	1106	1154	1178
8	1377	1058	1087	1116	1145	1175	1204	1233	1262	1291	1320	1349	1406	1435
8.5	1654	1273	1308	1343	1377	1412	1447	1481	1516	1550	1585	1619	1688	1722
9	1954	1509	1549	1590	1631	1671	1712	1752	1793	1833	1873	1914	1994	2034
9.5	2272	1762	1809	1856	1903	1950	1997	2043	2090	2136	2181	2226	2315	2358
10	2572	2014	2067	2120	2173	2226	2277	2328	2379	2430	2477	2524	2611	2650
10.5	2808	2257	2315	2373	2430	2488	2539	2590	2642	2693	2731	2770	2835	2863
11	2988	2483	2544	2606	2667	2729	2773	2818	2863	2908	2934	2961	3000	3012
11.5	3046	2682	2738	2793	2848	2904	2931	2959	2987	3015	3025	3035	3050	3054
12	3065	2847	2886	2926	2965	3004	3017	3029	3041	3054	3057	3061	3067	3069
12.5	3073	2960	2982	3004	3026	3048	3052	3057	3062	3067	3069	3071	3073	3074
13	3075	3023	3033	3044	3054	3065	3067	3069	3071	3073	3074	3074	3075	3075
13.5	3075	3052	3057	3062	3068	3073	3073	3074	3074	3075	3075	3075	3075	3075
14	3075	3069	3070	3072	3073	3075	3075	3075	3075	3075	3075	3075	3075	3075
14.5	3075	3073	3073	3074	3074	3075	3075	3075	3075	3075	3075	3075	3075	3075
15	3075	3074	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
15.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
16	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
16.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
17	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
17.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
18	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
18.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
19	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
19.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
20	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
20.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
21	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
21.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
22	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
22.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
23	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
23.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
24	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
24.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
25	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075

Table 12-1: Power Curves in kW for Mode 0. Conditions: 650V on low voltage side of high voltage transformer and wind speed given as 10 minutes average at hub height.

12.1.2 C_t Values

Wind speed [m/s]	Air density [kg/m³]													
	Standard 1.225	0.95	0.975	1	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3	0.913	0.916	0.915	0.915	0.915	0.915	0.914	0.914	0.914	0.914	0.913	0.913	0.913	0.913
3.5	0.865	0.867	0.867	0.867	0.867	0.867	0.867	0.866	0.866	0.866	0.866	0.866	0.865	0.865
4	0.833	0.834	0.834	0.834	0.834	0.834	0.834	0.833	0.833	0.833	0.833	0.833	0.833	0.832
4.5	0.821	0.823	0.823	0.823	0.823	0.823	0.823	0.822	0.822	0.822	0.822	0.821	0.821	0.821
5	0.817	0.820	0.820	0.820	0.819	0.819	0.819	0.819	0.818	0.818	0.818	0.818	0.817	0.817
5.5	0.815	0.818	0.818	0.817	0.817	0.817	0.817	0.816	0.816	0.816	0.816	0.815	0.815	0.814
6	0.812	0.816	0.815	0.815	0.815	0.814	0.814	0.813	0.813	0.813	0.812	0.812	0.811	0.811
6.5	0.808	0.813	0.812	0.812	0.811	0.811	0.811	0.810	0.810	0.809	0.809	0.808	0.807	0.807
7	0.804	0.810	0.810	0.809	0.808	0.808	0.807	0.807	0.806	0.806	0.805	0.805	0.803	0.803
7.5	0.800	0.807	0.807	0.806	0.805	0.805	0.804	0.804	0.803	0.802	0.802	0.801	0.799	0.799
8	0.798	0.806	0.805	0.804	0.804	0.803	0.802	0.801	0.801	0.800	0.799	0.798	0.797	0.796
8.5	0.794	0.803	0.802	0.801	0.801	0.800	0.799	0.798	0.797	0.796	0.796	0.795	0.793	0.792
9	0.781	0.791	0.790	0.789	0.789	0.788	0.787	0.786	0.785	0.784	0.783	0.782	0.780	0.779
9.5	0.755	0.767	0.767	0.766	0.765	0.764	0.763	0.762	0.761	0.760	0.758	0.756	0.752	0.750
10	0.711	0.733	0.732	0.731	0.730	0.729	0.727	0.725	0.723	0.722	0.718	0.715	0.705	0.698
10.5	0.643	0.691	0.690	0.688	0.686	0.685	0.681	0.676	0.672	0.668	0.660	0.651	0.633	0.623
11	0.567	0.646	0.643	0.640	0.638	0.635	0.627	0.619	0.611	0.603	0.591	0.579	0.554	0.541
11.5	0.480	0.597	0.590	0.583	0.576	0.570	0.557	0.545	0.533	0.520	0.507	0.493	0.469	0.457
12	0.409	0.542	0.531	0.519	0.508	0.496	0.483	0.470	0.456	0.443	0.432	0.420	0.400	0.390
12.5	0.353	0.481	0.468	0.454	0.441	0.428	0.416	0.404	0.393	0.381	0.372	0.362	0.345	0.338
13	0.308	0.421	0.408	0.395	0.383	0.370	0.361	0.351	0.341	0.332	0.324	0.316	0.301	0.295
13.5	0.272	0.369	0.358	0.347	0.336	0.325	0.317	0.308	0.300	0.292	0.285	0.278	0.266	0.261
14	0.241	0.323	0.314	0.305	0.296	0.286	0.279	0.272	0.265	0.258	0.253	0.247	0.236	0.232
14.5	0.216	0.286	0.278	0.270	0.263	0.255	0.249	0.243	0.237	0.231	0.226	0.221	0.211	0.207
15	0.194	0.255	0.248	0.242	0.235	0.228	0.223	0.217	0.212	0.207	0.203	0.198	0.190	0.186
15.5	0.175	0.229	0.223	0.217	0.211	0.205	0.201	0.196	0.191	0.187	0.183	0.179	0.172	0.168
16	0.159	0.207	0.202	0.196	0.191	0.186	0.182	0.178	0.174	0.169	0.166	0.162	0.156	0.153
16.5	0.145	0.188	0.183	0.179	0.174	0.169	0.165	0.162	0.158	0.154	0.151	0.148	0.142	0.140
17	0.133	0.171	0.167	0.163	0.159	0.154	0.151	0.148	0.144	0.141	0.138	0.135	0.130	0.128
17.5	0.122	0.156	0.153	0.149	0.145	0.141	0.138	0.135	0.132	0.129	0.127	0.124	0.119	0.117
18	0.112	0.144	0.140	0.137	0.133	0.130	0.127	0.124	0.122	0.119	0.117	0.114	0.110	0.108
18.5	0.103	0.132	0.129	0.126	0.123	0.120	0.117	0.115	0.112	0.110	0.108	0.106	0.102	0.100
19	0.096	0.122	0.120	0.117	0.114	0.111	0.109	0.106	0.104	0.102	0.100	0.098	0.094	0.093
19.5	0.089	0.113	0.111	0.108	0.106	0.103	0.101	0.099	0.097	0.094	0.093	0.091	0.088	0.086
20	0.083	0.105	0.103	0.101	0.098	0.096	0.094	0.092	0.090	0.088	0.086	0.085	0.082	0.080
20.5	0.077	0.098	0.096	0.094	0.091	0.089	0.087	0.086	0.084	0.082	0.080	0.079	0.076	0.075
21	0.072	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.078	0.077	0.075	0.074	0.071	0.070
21.5	0.068	0.086	0.084	0.082	0.080	0.078	0.077	0.075	0.073	0.072	0.071	0.069	0.067	0.066
22	0.064	0.080	0.079	0.077	0.075	0.073	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062
22.5	0.060	0.075	0.074	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062	0.061	0.059	0.058
23	0.056	0.071	0.069	0.068	0.066	0.065	0.063	0.062	0.061	0.060	0.059	0.057	0.056	0.055
23.5	0.053	0.067	0.065	0.064	0.062	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.052	0.052
24	0.050	0.063	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.053	0.052	0.051	0.049	0.049
24.5	0.048	0.059	0.058	0.057	0.056	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046
25	0.045	0.056	0.055	0.054	0.053	0.051	0.050	0.049	0.048	0.048	0.047	0.046	0.044	0.044

Table 12-2: C_t Values, Mode 0

12.1.3 Noise Levels

Conditions:	Measurement standard IEC 61400-11 ed. 2 2002 Wind shear: 0.16 Max. turbulence at 10 meter height: 16% Inflow angle (vertical): 0 ± 2º Air density: 1.225 kg/m^3		
Hub Height	**84 m**	**94 m**	**119 m**
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	94.7 4.2	94.7 4.3	94.7 4.5
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	97.3 5.6	97.5 5.7	98.1 5.9
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	100.9 7.0	101.2 7.2	101.9 7.4
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.3 8.4	104.5 8.6	105.1 8.9
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.0 9.8	106.5 10.0	106.5 10.4
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 11.2	106.5 11.4	106.5 11.9
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 12.7	106.5 12.9	106.5 13.4
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 14.1	106.5 14.3	106.5 14.9
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 15.5	106.5 15.7	106.5 16.3
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 16.9	106.5 17.2	106.5 17.8
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 18.3	106.5 18.6	106.5 19.3

Table 12-3: Mode 0 Noise Levels at Hub Height

12.2 Mode 1

12.2.1 Power Curves

Wind speed [m/s]	Air density [kg/m^3]													
	Standard 1.225	0.95	0.975	1	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3	23	13	14	14	15	16	17	18	19	20	21	22	24	25
3.5	68	41	44	46	48	51	53	56	58	61	63	66	71	73
4	130	88	92	96	99	103	107	111	114	118	122	126	133	137
4.5	202	145	150	155	161	166	171	176	181	187	192	197	207	212
5	291	214	221	228	235	242	249	256	263	270	277	284	298	305
5.5	404	301	311	320	329	339	348	357	367	376	385	394	413	422
6	540	407	419	431	443	455	467	480	492	504	516	528	552	564
6.5	701	533	548	563	579	594	609	625	640	655	671	686	717	732
7	891	681	700	719	738	757	777	796	815	834	853	872	910	929
7.5	1108	850	873	897	920	944	968	991	1015	1038	1061	1085	1131	1155
8	1354	1042	1070	1099	1127	1156	1184	1213	1241	1270	1298	1326	1383	1411
8.5	1630	1257	1291	1325	1359	1393	1427	1461	1494	1528	1562	1596	1663	1697
9	1931	1493	1533	1573	1613	1653	1693	1733	1772	1812	1852	1891	1970	2009
9.5	2251	1748	1794	1840	1887	1933	1979	2025	2071	2117	2161	2206	2294	2336
10	2554	2002	2055	2107	2160	2212	2263	2314	2364	2415	2461	2508	2593	2632
10.5	2794	2248	2306	2363	2420	2477	2528	2578	2629	2680	2718	2756	2821	2849
11	2976	2476	2536	2596	2656	2716	2760	2804	2848	2893	2920	2948	2988	3001
11.5	3040	2677	2730	2784	2837	2890	2919	2948	2977	3006	3017	3028	3044	3049
12	3063	2839	2878	2917	2956	2995	3009	3022	3036	3050	3054	3058	3065	3067
12.5	3072	2950	2973	2997	3020	3043	3049	3054	3060	3066	3068	3070	3072	3073
13	3075	3016	3028	3040	3051	3063	3065	3068	3070	3072	3073	3074	3075	3075
13.5	3075	3051	3056	3061	3067	3072	3073	3074	3074	3075	3075	3075	3075	3075
14	3075	3068	3070	3071	3073	3075	3075	3075	3075	3075	3075	3075	3075	3075
14.5	3075	3073	3073	3074	3074	3075	3075	3075	3075	3075	3075	3075	3075	3075
15	3075	3074	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
15.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
16	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
16.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
17	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
17.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
18	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
18.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
19	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
19.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
20	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
20.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
21	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
21.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
22	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
22.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
23	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
23.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
24	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
24.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
25	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075

Table 12-4: Power Curves in kW for Mode 1. Conditions: 650V on low voltage side of high voltage transformer and wind speed given as 10 minutes average at hub height.

12.2.2 C_t Values

Wind speed [m/s]	Air density [kg/m³]													
	Standard 1.225	0.95	0.975	1	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3	0.913	0.916	0.915	0.915	0.915	0.915	0.914	0.914	0.914	0.914	0.913	0.913	0.913	0.913
3.5	0.856	0.858	0.858	0.858	0.857	0.857	0.857	0.857	0.857	0.857	0.856	0.856	0.856	0.856
4	0.790	0.791	0.791	0.791	0.791	0.791	0.790	0.790	0.790	0.790	0.790	0.790	0.789	0.789
4.5	0.742	0.742	0.742	0.742	0.743	0.743	0.742	0.742	0.742	0.742	0.742	0.742	0.742	0.741
5	0.720	0.721	0.721	0.721	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.720	0.719	0.719
5.5	0.716	0.717	0.717	0.717	0.717	0.717	0.717	0.717	0.716	0.716	0.716	0.716	0.716	0.715
6	0.720	0.723	0.723	0.722	0.722	0.722	0.722	0.721	0.721	0.721	0.721	0.720	0.720	0.719
6.5	0.725	0.729	0.729	0.729	0.728	0.728	0.728	0.727	0.727	0.726	0.726	0.726	0.725	0.725
7	0.732	0.737	0.736	0.736	0.735	0.735	0.735	0.734	0.734	0.733	0.733	0.732	0.732	0.731
7.5	0.738	0.744	0.743	0.743	0.742	0.742	0.741	0.741	0.740	0.740	0.739	0.739	0.738	0.737
8	0.745	0.751	0.751	0.750	0.750	0.749	0.748	0.748	0.747	0.747	0.746	0.745	0.744	0.743
8.5	0.749	0.756	0.756	0.755	0.754	0.754	0.753	0.752	0.752	0.751	0.750	0.749	0.748	0.747
9	0.746	0.755	0.754	0.753	0.753	0.752	0.751	0.750	0.750	0.749	0.748	0.747	0.745	0.744
9.5	0.730	0.742	0.741	0.740	0.740	0.739	0.738	0.737	0.736	0.735	0.733	0.732	0.728	0.726
10	0.696	0.717	0.716	0.715	0.714	0.713	0.712	0.710	0.708	0.706	0.703	0.700	0.690	0.684
10.5	0.634	0.682	0.680	0.679	0.677	0.676	0.671	0.667	0.663	0.659	0.651	0.643	0.625	0.615
11	0.562	0.641	0.638	0.634	0.631	0.628	0.620	0.612	0.604	0.596	0.585	0.573	0.549	0.537
11.5	0.478	0.593	0.585	0.578	0.571	0.564	0.552	0.540	0.529	0.517	0.504	0.491	0.467	0.456
12	0.408	0.538	0.527	0.516	0.505	0.494	0.481	0.468	0.455	0.442	0.431	0.419	0.399	0.390
12.5	0.353	0.477	0.464	0.452	0.439	0.427	0.415	0.404	0.392	0.381	0.371	0.362	0.345	0.337
13	0.308	0.418	0.406	0.394	0.382	0.370	0.360	0.351	0.341	0.331	0.324	0.316	0.301	0.295
13.5	0.272	0.369	0.358	0.347	0.336	0.325	0.316	0.308	0.300	0.292	0.285	0.278	0.266	0.260
14	0.241	0.323	0.314	0.305	0.296	0.286	0.279	0.272	0.265	0.258	0.253	0.247	0.236	0.232
14.5	0.216	0.286	0.278	0.270	0.263	0.255	0.249	0.243	0.237	0.231	0.226	0.221	0.211	0.207
15	0.194	0.255	0.248	0.242	0.235	0.228	0.223	0.217	0.212	0.207	0.203	0.198	0.190	0.186
15.5	0.175	0.229	0.223	0.217	0.211	0.205	0.201	0.196	0.191	0.187	0.183	0.179	0.172	0.168
16	0.159	0.207	0.202	0.196	0.191	0.186	0.182	0.178	0.174	0.169	0.166	0.162	0.156	0.153
16.5	0.145	0.188	0.183	0.179	0.174	0.169	0.165	0.162	0.158	0.154	0.151	0.148	0.142	0.140
17	0.133	0.171	0.167	0.163	0.159	0.154	0.151	0.148	0.144	0.141	0.138	0.135	0.130	0.128
17.5	0.122	0.156	0.153	0.149	0.145	0.141	0.138	0.135	0.132	0.129	0.127	0.124	0.119	0.117
18	0.112	0.144	0.140	0.137	0.133	0.130	0.127	0.124	0.122	0.119	0.117	0.114	0.110	0.108
18.5	0.103	0.132	0.129	0.126	0.123	0.120	0.117	0.115	0.112	0.110	0.108	0.106	0.102	0.100
19	0.096	0.122	0.120	0.117	0.114	0.111	0.109	0.106	0.104	0.102	0.100	0.098	0.094	0.093
19.5	0.089	0.113	0.111	0.108	0.106	0.103	0.101	0.099	0.097	0.094	0.093	0.091	0.088	0.086
20	0.083	0.105	0.103	0.101	0.098	0.096	0.094	0.092	0.090	0.088	0.086	0.085	0.082	0.080
20.5	0.077	0.098	0.096	0.094	0.091	0.089	0.087	0.086	0.084	0.082	0.080	0.079	0.076	0.075
21	0.072	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.078	0.077	0.075	0.074	0.071	0.070
21.5	0.068	0.086	0.084	0.082	0.080	0.078	0.077	0.075	0.073	0.072	0.071	0.069	0.067	0.066
22	0.064	0.080	0.079	0.077	0.075	0.073	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062
22.5	0.060	0.075	0.074	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062	0.061	0.059	0.058
23	0.056	0.071	0.069	0.068	0.066	0.065	0.063	0.062	0.061	0.060	0.059	0.057	0.056	0.055
23.5	0.053	0.067	0.065	0.064	0.062	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.052	0.052
24	0.050	0.063	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.053	0.052	0.051	0.049	0.049
24.5	0.048	0.059	0.058	0.057	0.056	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046
25	0.045	0.056	0.055	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046	0.045	0.044

Table 12-5: C_t Values, Mode 1

12.2.3 Noise Levels

Conditions: Measurement standard IEC 61400-11 ed. 2 2002 Wind shear: 0.16 Max. turbulence at 10 meter height: 16% Inflow angle (vertical): 0 ± 2º Air density: 1.225 kg/m^3			
Hub Height	**84 m**	**94 m**	**119 m**
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	94.3 4.2	94.3 4.3	94.4 4.5
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hh [m/sec]	96.5 5.6	96.5 5.7	97.0 5.9
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	99.8 7.0	100.2 7.2	100.8 7.4
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	103.2 8.4	103.5 8.6	104.3 8.9
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.0 9.8	106.5 10.0	106.5 10.4
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 11.2	106.5 11.4	106.5 11.9
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 12.7	106.5 12.9	106.5 13.4
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 14.1	106.5 14.3	106.5 14.9
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 15.5	106.5 15.7	106.5 16.3
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 16.9	106.5 17.2	106.5 17.8
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	106.5 18.3	106.5 18.6	106.5 19.3

Table 12-6: Mode 1 Noise Levels at Hub Height

12.3 Mode 2

12.3.1 Power Curves

Wind speed [m/s]	Air density [kg/m^3]													
	Standard 1.225	0.95	0.975	1	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3	23	13	14	14	15	16	17	18	19	20	21	22	24	25
3.5	68	41	44	46	48	51	53	56	58	61	63	66	71	73
4	130	88	92	96	100	104	107	111	115	119	123	126	134	138
4.5	206	148	153	158	164	169	174	180	185	190	196	201	212	217
5	301	221	228	236	243	250	257	265	272	279	286	294	308	315
5.5	417	311	321	330	340	350	359	369	378	388	398	407	427	436
6	556	419	431	444	456	469	481	494	506	518	531	543	568	581
6.5	719	546	561	577	593	609	625	640	656	672	688	703	735	751
7	910	694	714	733	753	773	792	812	832	851	871	890	929	949
7.5	1127	863	887	911	935	960	983	1007	1031	1055	1079	1103	1151	1174
8	1370	1053	1082	1111	1140	1169	1197	1226	1255	1284	1312	1341	1398	1427
8.5	1632	1259	1293	1327	1361	1395	1429	1463	1497	1531	1564	1598	1665	1699
9	1905	1474	1513	1553	1592	1632	1671	1710	1749	1788	1827	1866	1944	1983
9.5	2180	1692	1736	1781	1826	1871	1915	1959	2004	2048	2092	2136	2222	2265
10	2436	1898	1948	1998	2048	2098	2147	2196	2245	2294	2341	2389	2479	2522
10.5	2660	2093	2147	2201	2256	2310	2362	2415	2467	2519	2566	2613	2695	2730
11	2845	2278	2336	2394	2452	2510	2563	2616	2669	2722	2763	2804	2868	2890
11.5	2952	2453	2512	2572	2632	2691	2737	2783	2828	2874	2900	2926	2964	2975
12	3012	2623	2678	2733	2788	2843	2875	2908	2940	2973	2986	2999	3017	3022
12.5	3045	2781	2824	2868	2912	2955	2973	2991	3009	3026	3032	3038	3046	3048
13	3060	2910	2937	2964	2991	3019	3027	3036	3044	3053	3055	3058	3061	3061
13.5	3069	2982	2999	3015	3031	3048	3052	3057	3061	3065	3066	3068	3069	3069
14	3073	3033	3041	3049	3057	3065	3066	3068	3070	3071	3072	3072	3073	3073
14.5	3074	3059	3062	3065	3068	3071	3072	3072	3073	3074	3074	3074	3074	3074
15	3075	3069	3070	3071	3073	3074	3074	3074	3074	3075	3075	3075	3075	3075
15.5	3075	3073	3073	3074	3074	3075	3075	3075	3075	3075	3075	3075	3075	3075
16	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
16.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
17	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
17.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
18	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
18.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
19	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
19.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
20	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
20.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
21	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
21.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
22	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
22.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
23	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
23.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
24	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
24.5	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075
25	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075	3075

Table 12-7: Power Curves in kW for Mode 2. Conditions: 650V on low voltage side of high voltage transformer and wind speed given as 10 minutes average at hub height.

12.3.2 C_t Values

Wind speed [m/s]	Air density [kg/m^3]													
	Standard 1.225	0.95	0.975	1	1.025	1.05	1.075	1.1	1.125	1.15	1.175	1.2	1.25	1.275
3	0.913	0.916	0.915	0.915	0.915	0.915	0.914	0.914	0.914	0.914	0.913	0.913	0.913	0.913
3.5	0.865	0.867	0.867	0.867	0.867	0.866	0.866	0.866	0.866	0.866	0.866	0.865	0.865	0.865
4	0.826	0.827	0.827	0.827	0.827	0.827	0.827	0.827	0.826	0.826	0.826	0.826	0.826	0.825
4.5	0.808	0.810	0.810	0.810	0.810	0.809	0.809	0.809	0.809	0.809	0.808	0.808	0.808	0.808
5	0.802	0.805	0.804	0.804	0.804	0.804	0.803	0.803	0.803	0.803	0.802	0.802	0.802	0.802
5.5	0.798	0.800	0.800	0.800	0.799	0.799	0.799	0.799	0.798	0.798	0.798	0.798	0.797	0.797
6	0.795	0.799	0.798	0.798	0.798	0.797	0.797	0.797	0.796	0.796	0.796	0.795	0.795	0.794
6.5	0.792	0.797	0.796	0.796	0.795	0.795	0.794	0.794	0.794	0.793	0.793	0.792	0.791	0.791
7	0.789	0.794	0.794	0.793	0.793	0.792	0.792	0.791	0.791	0.790	0.790	0.789	0.788	0.787
7.5	0.782	0.789	0.789	0.788	0.787	0.787	0.786	0.786	0.785	0.784	0.784	0.783	0.782	0.781
8	0.771	0.779	0.778	0.777	0.777	0.776	0.775	0.775	0.774	0.773	0.773	0.772	0.770	0.770
8.5	0.751	0.758	0.758	0.757	0.756	0.756	0.755	0.754	0.754	0.753	0.752	0.751	0.750	0.749
9	0.719	0.727	0.726	0.725	0.725	0.724	0.723	0.722	0.722	0.721	0.720	0.720	0.718	0.717
9.5	0.678	0.685	0.685	0.684	0.683	0.683	0.682	0.681	0.681	0.680	0.679	0.678	0.676	0.675
10	0.629	0.638	0.637	0.637	0.636	0.636	0.635	0.634	0.633	0.633	0.631	0.630	0.627	0.624
10.5	0.575	0.588	0.588	0.587	0.587	0.586	0.585	0.584	0.583	0.582	0.580	0.577	0.570	0.565
11	0.517	0.541	0.541	0.540	0.539	0.538	0.536	0.535	0.533	0.531	0.526	0.522	0.509	0.501
11.5	0.455	0.497	0.496	0.495	0.494	0.492	0.489	0.485	0.481	0.477	0.470	0.462	0.446	0.438
12	0.398	0.459	0.456	0.453	0.450	0.448	0.441	0.435	0.429	0.423	0.414	0.406	0.389	0.381
12.5	0.348	0.423	0.418	0.413	0.409	0.404	0.396	0.388	0.380	0.372	0.364	0.356	0.341	0.333
13	0.306	0.388	0.381	0.374	0.367	0.360	0.352	0.344	0.336	0.328	0.320	0.313	0.299	0.293
13.5	0.271	0.350	0.343	0.335	0.327	0.320	0.312	0.305	0.298	0.290	0.284	0.277	0.265	0.260
14	0.241	0.315	0.308	0.300	0.292	0.285	0.278	0.271	0.265	0.258	0.252	0.247	0.236	0.231
14.5	0.216	0.283	0.276	0.269	0.261	0.254	0.248	0.242	0.236	0.230	0.226	0.221	0.211	0.207
15	0.194	0.254	0.247	0.241	0.234	0.228	0.223	0.217	0.212	0.207	0.202	0.198	0.190	0.186
15.5	0.175	0.229	0.223	0.217	0.211	0.205	0.201	0.196	0.191	0.187	0.183	0.179	0.172	0.168
16	0.159	0.207	0.202	0.196	0.191	0.186	0.182	0.178	0.174	0.169	0.166	0.162	0.156	0.153
16.5	0.145	0.188	0.183	0.179	0.174	0.169	0.165	0.162	0.158	0.154	0.151	0.148	0.142	0.140
17	0.133	0.171	0.167	0.163	0.159	0.154	0.151	0.148	0.144	0.141	0.138	0.135	0.130	0.128
17.5	0.122	0.156	0.153	0.149	0.145	0.141	0.138	0.135	0.132	0.129	0.127	0.124	0.119	0.117
18	0.112	0.144	0.140	0.137	0.133	0.130	0.127	0.124	0.122	0.119	0.117	0.114	0.110	0.108
18.5	0.103	0.132	0.129	0.126	0.123	0.120	0.117	0.115	0.112	0.110	0.108	0.106	0.102	0.100
19	0.096	0.122	0.120	0.117	0.114	0.111	0.109	0.106	0.104	0.102	0.100	0.098	0.094	0.093
19.5	0.089	0.113	0.111	0.108	0.106	0.103	0.101	0.099	0.097	0.094	0.093	0.091	0.088	0.086
20	0.083	0.105	0.103	0.101	0.098	0.096	0.094	0.092	0.090	0.088	0.086	0.085	0.082	0.080
20.5	0.077	0.098	0.096	0.094	0.091	0.089	0.087	0.086	0.084	0.082	0.080	0.079	0.076	0.075
21	0.072	0.091	0.089	0.087	0.085	0.083	0.082	0.080	0.078	0.077	0.075	0.074	0.071	0.070
21.5	0.068	0.086	0.084	0.082	0.080	0.078	0.077	0.075	0.073	0.072	0.071	0.069	0.067	0.066
22	0.064	0.080	0.079	0.077	0.075	0.073	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062
22.5	0.060	0.075	0.074	0.072	0.070	0.069	0.067	0.066	0.065	0.063	0.062	0.061	0.059	0.058
23	0.056	0.071	0.069	0.068	0.066	0.065	0.063	0.062	0.061	0.060	0.059	0.057	0.056	0.055
23.5	0.053	0.067	0.065	0.064	0.062	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.052	0.052
24	0.050	0.063	0.061	0.060	0.059	0.057	0.056	0.055	0.054	0.053	0.052	0.051	0.049	0.049
24.5	0.048	0.059	0.058	0.057	0.056	0.054	0.053	0.052	0.051	0.050	0.049	0.048	0.047	0.046
25	0.045	0.056	0.055	0.054	0.053	0.051	0.050	0.049	0.048	0.048	0.047	0.046	0.044	0.044

Table 12-8: C_t Values, Mode 2

12.3.3 Noise Levels

Conditions:	Measurement standard IEC 61400-11 ed. 2 2002 Wind shear: 0.16 Max. turbulence at 10 meter height: 16% Inflow angle (vertical): 0 ± 2º Air density: 1.225 kg/m³		
Hub Height	**84 m**	**94 m**	**119 m**
LwA @ 3 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	94.7 4.2	94.7 4.3	94.7 4.5
LwA @ 4 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	97.3 5.6	97.5 5.7	98.1 5.9
LwA @ 5 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	100.9 7.0	101.2 7.2	101.9 7.4
LwA @ 6 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 8.4	104.5 8.6	104.5 8.9
LwA @ 7 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 9.8	104.5 10.0	104.5 10.4
LwA @ 8 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 11.2	104.5 11.4	104.5 11.9
LwA @ 9 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 12.7	104.5 12.9	104.5 13.4
LwA @ 10 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 14.1	104.5 14.3	104.5 14.9
LwA @ 11 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 15.5	104.5 15.7	104.5 16.3
LwA @ 12 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 16.9	104.5 17.2	104.5 17.8
LwA @ 13 m/s (10 m above ground) [dBA] Wind speed at hub height [m/s]	104.5 18.3	104.5 18.6	104.5 19.3

Table 12-9: Mode 2 Noise Levels at Hub Height

V112, Check Mechanical and Electrical Part

- **Extract Gear Oil Sample**

Extract a sample of gear oil according to the instructions given in SWI 959406 'Extraction of Oil Samples in Service'. ▷ Draw the sample within 25 minutes after the turbine has stopped.	1 year

- **Extract Hydraulic Oil Sample**

Extract a sample of gear oil according to the instructions given in SWI 959406 'Extraction of Oil Samples in Service'. ▷ Draw the sample within 25 minutes after the turbine has stopped.	1 year

- **Test of Emergency Stop Buttons in the Nacelle**

Test the following emergency stop buttons according to the procedure below: • Top controller. • Yaw plate. • Gearbox. 1. Bring the turbine to 'stop' or 'pause' mode. 2. Press the emergency stop button and check that the turbine changes to 'emergency stop' mode. Turn the emergency stop button counter clockwise to release it.	1 year

- **Replacement of Air Filters in Controller Cabinets**

Replace the following air filters as described in the procedure below: **Inlet Filters** Bottom of distribution/control section Power section above generator Front side of bus bar section above converter cabinet **Outlet Filters** Top of distribution/control section Rear side of power section above generator	1 year

Rear side of bus bar section above converter cabinet Emergency lubrication controller cabinet above gearbox	

- **<u>Generator</u>**

1. Clean the drip pans below the grease outlets at the generator bearings. 2. Refill the automatic lubricator via the grease inlet at the rear end of the controller cabinet above the generator. 3. Remove the grease hoses from the quick-acting couplings at the generator bearings. 4. Run the automatic lubricator manually and check that grease is flowing from both hoses. ⇘ In case grease is not flowing evenly from the hoses, clean or replace the hoses and repair/replace the automatic lubricator. 5. Remount the grease hoses. 6. Set the automatic lubricator back to auto mode.	3 mounth	1 year

- **<u>Test of Trip Q8</u>**

1. Switch the controller to ‘STOP’ or ’PAUSE’. 2. Select picture 13 ‘DIGITAL OUTPUT’. 3. Select K127 ‘Disconnect Q8’. 4. Press <FUNC> to activate the cursor. 5. Press <1><ENTER> to trip Q8. 6. Press <FUNC> followed by <0> <ENTER>. 7. Press <FUNC> followed by <ESC>. Connect the breaker again: 1. Select K126 ‘Connect Q8’. 2. Press <FUNC> to activate the cursor. 3. Press <1><ENTER> to connect Q8. 4. Press <FUNC> followed by <0> <ENTER>. 5. Press <FUNC> followed by <ESC>.	1 year

- **<u>Bolts Connecting Generator and Main Foundation</u>**

Check every 3rd M24 bolt between the generator foundation and the main foundation. ▷ *For hydraulic tensioner settings, see document 920098 ‘Torque Wrench Settings’ or 960501 ‘Bolt Connections’.*	First 3 months

- **<u>Composite Coupling</u>**

Check for Cracks and Delaminating ▶Check for cracks and delaminating in the reinforced area around the bolt holes.	First 3 months	1 year

▶ Serious resin cracks and delamination can be identified by a lighter colour than usual. Such defects are unacceptable. See document 945578 'Check/Inspection of Composite Coupling'.		

- **<u>Gear Swarf Indicators</u>**

1. Check the input signals from the swarf indicators on the return hoses to the gear oil tank. 2. Regardless of swarf indicators showing a high signal, always remove and visually inspect the indicators in charge. Clean the indicators. 3. Remove the magnets next to the swarf indicators and clean them. 4. Report any findings to Vestas Wind Systems A/S.	1 year

- **<u>Gear Oil Change</u>**

▶ Change oil according to oil sample analyses. Any oil change will appear in the service report.	Acc. To analysis

- **<u>Gear Replacement of Offline Filters</u>**

▶ Replacement of Offline Filters	Acc. to lubrication chart

- **<u>Gear Check for Leakages</u>**

▶ Check joints, seals and covers for leakages.	1 year

- **<u>Gear Check of Oil Level</u>**

1. Check that the temperature is at least 45℃ in gear and oil tank at all sensors: – Sensor B402A: Oil temp. in reservoir – Sensor B402B: Oil temp. in GBX manifold – Sensor B406A: Temperature, gear bearing, HS rotor end – Sensor B406B: Temperature, gear bearing, HS generator end – Sensor B406C: Temperature, gear bearing, HS middle – Sensor B406D: Temperature, gear bearing, hollow shaft rotor end	1 year

– Sensor B406E: Temperature, gear bearing, hollow shaft generator end Otherwise, let the turbine run until the temperature is reached. 2. Bring the turbine to 'PAUSE' mode and check that the gear oil pump is still running. 3. Wait for minimum 5 minutes to allow the oil level in the base tank to stabilize and the temperature differences to even out: (B402A - B406A: equal ±3℃). 4. Go to test for checking the oil level.	

- **Gear Cooler**

1. Check seals and gaskets. 2. Check hoses for marks and cracks.	1 year

- **Gear Pumps and Valves**

1. Check fittings and flange connections for leakages. 2. Check that all valves are open.	1 year

- **Visual Leak Check – Pipes, Hoses and Hose Clips**

1. Check the hoses from the VCS section to the pump. 2. Check seals. 3. Check the hoses from the pump to the cooler. 4. Check seals. 5. Check hose clips. 6. Tighten them if necessary.	1 year

- **Reinforcement Beam Bolts**

▶ Check 3 of the M36 bolts at each end of the 2 reinforcement beams. For hydraulic tensioner setting, see document 920098 'Torque Wrench Settings' or and 960501 'Bolt Connections'.	First 3 months

- **Brake Pressure**

1. Connect the digital pressure gauge 2. Switch the turbine to 'PAUSE' mode. ▷ Correct pressure: 50/60 Hz turbine: Pump start pressure. Pump stop pressure. 1. Go to test to monitor the brake pressure. 3. Compare the pressure displayed in the digital pressure	1 year

gauge placed on gauge connector with the pressure displayed in the service panel. ▷ Maximum deviation is 1 bar. *4.* List 2 values observed simultaneously.	

- **Pre-charge Pressure in Pitch Accumulator**

1. Press an emergency stop button. 2. Open all needle valves in the hub in order to release the pressure from the system. 3. Wait for 5 minutes to let the temperature stabilise. Accumulator pre-charge pressure according to document 941918 ‘Charging of Nitrogen Accumulators’. 4. Measure and, if necessary, refill the pitch accumulators pos. S2. ▶ Temperature in hub ▶ Pre-charge pressure before adjustment: Blade A Blade B Blade C ▶ Common accumulator ▶ Pre-charge pressure after adjustment: Blade A Blade B Blade C ▶ Common accumulator ▶ Leak spray test OK	1 year

- **Test of Emergency Valve**

1. Pitch the blades to 90°. 2. Bring the turbine to ‘STOP’ mode. 3. Press <FUNC> to set the system into ‘MANUAL’ mode. 4. Press <2> to start the offline pump. 5. Wait for minimum 30 seconds. 6. Press <1> to start the high pressure pump. 7. Press <5> to switch to high pressure reference. 8. Wait until the pressure in the accumulators reaches maximum system pressure. 9. Toggle the emergency valves on the pitch blocks by pressing <7>, <8> and <9>, and finally the common emergency valve by pressing <6>. 10. Observe that the drain pressure is relieved to the tank.	1 year

- **Check of Hydraulic Cylinder Piston**

1. Dismount the seal savers on the piston rods. 2. Check the piston rods for scratches or any signs of wear or	1 year

damage of packed glands. 1. If any marks/signs are found, a note should be made in the service report.	

- **Bolts connecting Blade and Blade Bearing**

1. *After first 3 months check every 3rd of the M30 blade bolts (stud bolts) between each blade and blade bearing.* For hydraulic tensioner settings, see document 920098 'Torque Wrench Settings' or 960501 'Bolt Connections'. 2. After 4 years check every 10th (count forwards) of the M30 blade bolts (studs) between each blade and blade bearing. 3. The nut is considered to be loose if it can be turned. Then check all nuts in that blade bearing/blade assembly. 4. To see how much the nut has been turned, use a scriber (marking tool) to make a mark on the washer against 1 of the edges of the nut. *5.* When the tensioner is dismounted, the distance between the mark and the edge of the nut can be measured.	First 3 mounth	4 years

- **Bolts Connecting Blade Bearing and Hub**

▶ *After first 3 months check every 3rd bolt connecting each blade bearing and the hub.* ▶ After 4 years check every 10th bolt (count forwards) connecting each blade bearing and the hub. Use the same procedure as described in section 32.1 Bolts connecting Blade and Blade Bearing, p. 51.	First 3 mounth	4 years

- **Tower Bottom Flange Bolts**

▶ Check 6 bolts between the bottom flange and the section flange. The 6 bolts must be evenly distributed, approximately 60° between each bolt. ▶ Check all bolts if one or more bolts have lost tension. For torque wrench settings, see document 920098 'Torque Wrench Settings' or 960501 'Bolt Connections'.	First 3 mounth	4 years

- **Section Flange Bolts**

▶ Check 6 bolts between each of the section flanges. The 6 bolts must be evenly distributed, approximately 60° between each bolt.	First 3 mounth	4 years

▶ Check all bolts if one or more bolts have lost tension. For torque wrench settings, see document 920098 'Torque Wrench Settings' or 960501 'Bolt Connections'.		

- **Service Lift**

1. Check the service lift according to the **supplier's user manual**. ▷ If the manual is not present in the turbine, order it. 2. Fill in the test report. 3. Check the earth leak circuit breaker F61 inside the ground controller by pressing test button.	1 year

- **UPS Battery Check**

▶ Check that 5 LEDs are on in the right column of LEDs on the UPS controller.	1 year

- **Test of UPS (Turbine Shut Down)**

▶ Change the settings of the buttons of the timers K3 and K4 according to the table below:

Timer	Time Sector	Time Value
K3	100S	6
K4	100S	6.5

Check that the battery charge indicators are on.

Interval: 1 year

- **HV Transformer & Transformer Room - Inspection**

▶ Inspect the high voltage transformer and the transformer room as described in document 961117 'Inspection of Transformer and Transformer Room'.	1 year

- **Final Visual Check**

1. At inspection of machinery, always look very carefully for oil waste and loose bolts. 2. At the covers and shaft lead-ins, the gearbox can 'sweat' a little. This, along with brake dust, can soil the gearbox. Wipe off the dirt. Otherwise, it can be difficult to determine if there is a significant leak. A significant leak is when oil drops run down the gearbox. Such a leak means oil waste to such an extent	3 mounth	1 year

that repair is necessary. 3. Loose bolts in the structure represent danger. They must be tightened immediately.		