Refurbished

Vestas

V17 V19 V20

Wind Turbine

Operation & Maintenance Manual


MWPS

This manual is for the installation, operation and maintenance of refurbished Vestas V17, V19 and V20 Wind Turbines from Enertech.

The manual consists of sheets from the original Vestas manuals, and includes operational instructions on a new Programmable Logic Control (PLC) controller that replaces the original Vestas control system.

All three models are similar in operation. The V17 and V19 feature two generators, one that operates in low wind speeds, and a larger generator that connects when wind speed increases. The V20 turbine only has one generator.

In most cases, the original Vestas control system has been replaced with a new PLC controller. For those turbines, go to the back of this manual for operation of the PLC (HPS) controller.

In some cases, buyers want the original control system from Vestas. For those models, we have included operational instructions on both relay based, and microcomputer-based controllers.

We ask that you pay close attention to the section on safety, and recommend you take additional instruction on safety equipment and procedures, including proper tower climbing procedures.

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1. PREFACE

PREFACE

Your Vestas V 17/75 kW wind turbine is a small power station connected with the public utility and your consumption.

In order to obtain a satisfactory operation, minor costs of maintenance, and a long working life it is a condition that the turbine is operated, maintained, and examined according to Vestas' recommendations in this operating instruction.

As the owner of the turbine it is your responsibility that the turbine is not operated by unskilled persons.

Before you or another person starts operating the turbine you must as a minimum have studied the following carefully:

Security regulations for operator or serviceman, and
Operating instruction for Vestas V 17/75 kW wind turbine.

Do not refrain from contacting your authorized serviceman or Vestas' service department if you find faults or want an elaborated understanding for some items.

Address:
VESTAS ENERGY A/S
POSTBOX 42
DK 6940 LEM
DENMARK

Telephone:
+45-7-34 11 88

Telex:
60 733
VESTAS DK

Telefax:
+45 7 34 14 84

Postgiro:
8 84 73 98

Bank:
A/S RINGKØBING BANK
7650-200717-2
DEN DANSKE BANK
3403-14700-1

A/S Reg.:
65 903

Note: blades used are always from matched original sets. Geocorp does not purchase turbines in portions and re-assemble major components from different units. Original sets have been matched by weight and balanced by Vestas at time of manufacture. All blades contain original Vestas stamping and are from original matched sets, not made up of miscellaneous blades from multiple turbines.

Brake system
- Calipers are overhauled using parts supplied by original manufacturer (Brembo)
- System is flushed, cleaned, new brake fluid is added
- Hoses, compression fittings, wiring are replaced as needed
- Brake motor, electronics (relays, solenoid valve, coil for solenoid valve, wiring), reservoir, reservoir gasket, etc. are replaced and upgraded as needed
- Brake pads replaced as needed
- Nitrogen tank replaced and recharged

Nacelle cover
- Springs are replaced
- Cover cleaned, repaired as necessary, and coated

Machine Bedplate
Mechanical and chemical surface prep prior to coating application

Tower
Mechanical and chemical surface prep prior to coating application

Gearbox
Gearbox overhaul and parts replacement as necessary such that only gears, pinions and other parts in new, excellent or mint condition are re-deployed. Shim and tensioning as necessary. All interior parts cleaned prior to replacement of gear oil.

Generator
Rewind or recondition winding as necessary, dip & bake 100% epoxy, sandblast stator and end bells, dynamically balance rotating element, replace bearings, steam clean all parts, apply new coating. Replace belt drive on the two generators.

High speed shaft
Install new OEM cardan joints

Controller
Original analog/relay based controller replaced with modern, new soft start controller supplied for robust user control.

Yaw motor/gear mechanism
- Overhaul using approved parts supplied by original manufacturer, (Bonfiglioni), sand blast, apply new coating.
- Replace yaw gear as needed
- Overhaul cable twist mechanism

Misc. sensors
- Install new anemometer and wind vane (high quality stainless steel and brass sensors used, not plastic)
- Install new high speed and low speed RPM sensors as needed

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Product description Vestas Wind Turbines

Model V17/75 kW

17 m rotor diameter

The Vestas V17/75 kW is a three bladed horizontal axis wind turbine that features a 17 mtr. diameter rotor and a 90 kW nominal output generator. Based on the successful design of the V16/55 kW model, the V17/75 kW's predecessor, the V17/75 kW was introduced to commercial markets in August 1984 and has subsequently gained a leading position on the world market.

The machine will be described according to the following main areas:

1. Rotor
2. Transmission system and generators
3. Yawing system
4. Microprocessor control unit
5. Main data
6. Power curve

1. Rotor

Three aerodynamically designed rotor blades are connected to the main shaft by a rigid hub. The rotor blades are made of reinforced polyester fiberglass. As an up-wind wind turbine, the rotor is positioned in front of the tower with respect to the wind's direction. This design feature allows the wind turbine to extract maximum power immediately from the wind while avoiding interference from the tower.

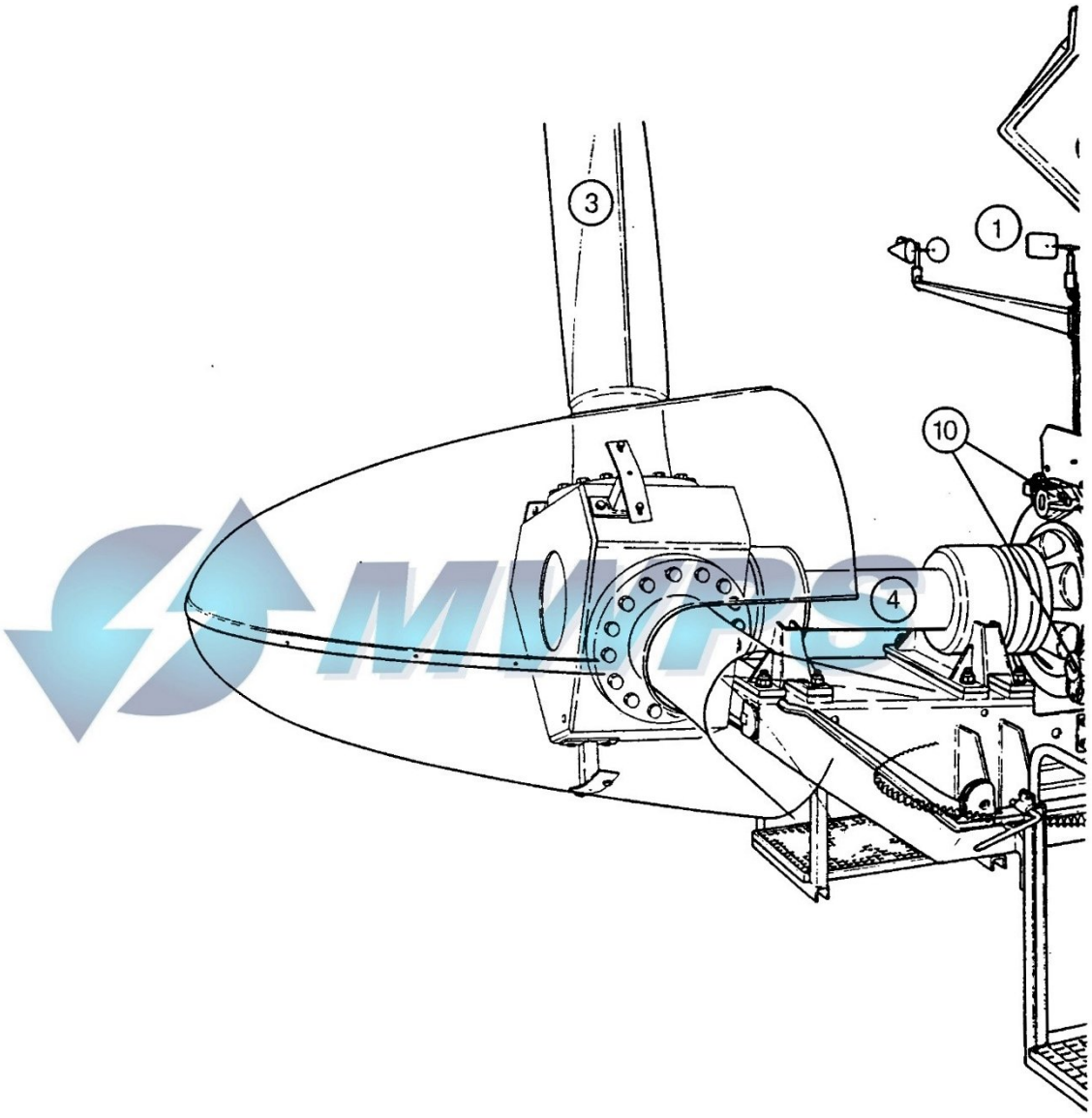
For overspeed protection, the rotor is equipped with centrifugally activated blade tips which pivot 90 degrees and act as an aerodynamic brake.

2. Transmission system and generators

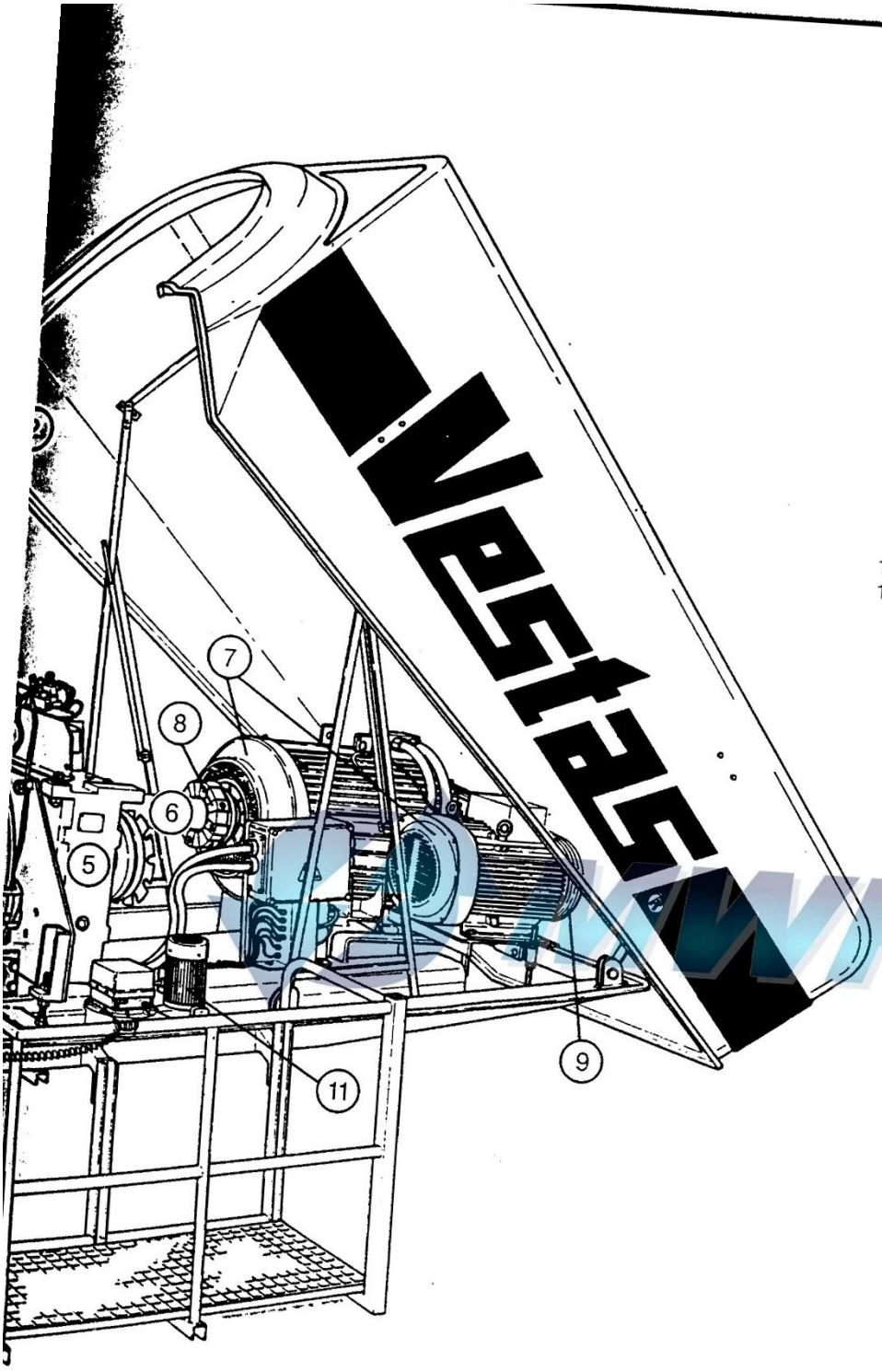
The torque from the rotor is transmitted through the main shaft to the gear box and then through a high speed shaft to the asynchronous generators. The main shaft is supported by two sets of specially designed roller bearings that absorb both axial and radial forces and provide an extended life with minimum maintenance. A flex-coupling at either end of the high speed shaft ensures precision alignment and maximum torque transmission from the gear box to the generator.

Two generators - one for low and one for high wind speeds - provide the basis for efficient electricity production across the full range of available wind speeds. At low wind speeds, the small generator remains connected and operable. However, once prevailing wind speeds reach the main generator's efficient production level, the small generator automatically disconnects and the main generator takes over.

Machine structure



A disc brake is located directly on the main shaft to stop the rotor when necessary and to lock the rotor when wind speeds reach a certain level. Positioned to ensure that the braking load effect is not transferred to the gear box, the disc brake is equipped with hydraulic applied brake calipers which close firmly onto the disc when the brake system is activated. - As a fail-safe brake system, an accumulator maintains a resevoir of hydraulic pressure so that sufficient braking pressure is always available.



1. Electronic wind vane
2. Nacelle cover
3. Rotor blade
4. Main shaft
5. Gear box
6. High speed shaft
7. Generators
8. Flexible coupling
9. V-belt drive
10. Disc brake calipers
11. Electric yawing motor

3. Yawing system

The active electric drive yawing system receives its signal from the electronic wind vane mounted on the nacelle. This impulse is fed through a time delay circuit to the electric yawing motor which slowly pivots the entire nacelle into the wind until the wind vane returns to a neutral position.

As an additional safety feature the yawing system automatically pivots the nacelle 90 degrees out of the wind to prevent damage in the event that excess wind, overspeed due to grid failure, etc. activates one of the wind turbine's safety functions.

4. Microprocessor control unit

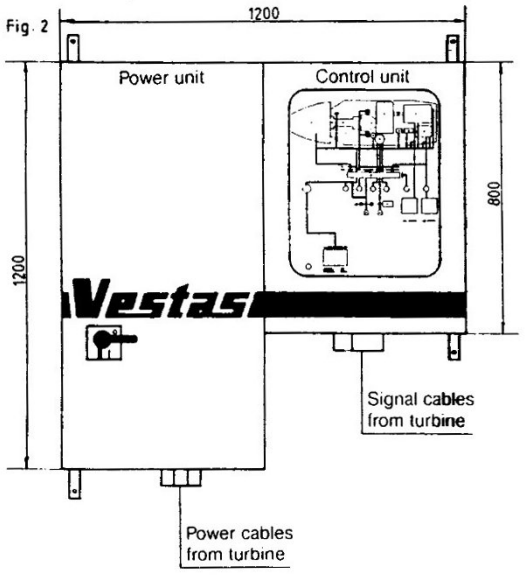
All of the wind turbine's functions are managed and regulated by an electronic control unit that has been specially designed and programmed by Vestas. This control unit is microprocessor based and thus, offer a significantly wider range of control features.

The control unit itself consists of a power unit and an operating and control unit. As the junction between the wind turbine and the utility grid, the power unit receives the electricity produced by the wind turbine through one set of cables and then releases that electricity into the utility grid through another set of cables.The operating and control unit, however, houses the microprocessor which coordinates the wind turbine's productive and safety functions with the current conditions in the external environment. This unit is placed on a flow diagram and protected by a door of transparent acrylic. The flow diagram indicates the location of all vital instruments and includes a display of rotor speed, wind speed and kilowatt production plus the current status of the yawing and brake systems.

The entire electronic control unit is normally placed in a waterproof cabinet at the base of the tower or some other location which is in the immediate vicinity of the wind turbine. However, for multi-unit installations (wind parks) or installations in remote areas, the control unit can be accessed from another location via a modem.

Control panel

Fig. 2

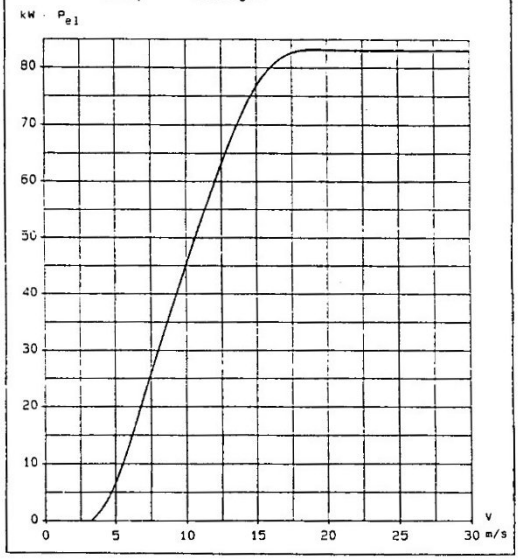


5. Main Data

Vestas 17/75 kW	
Rotor diameter	17,0 mtrs.
Swept area	227 m²
Blade type	Vestas 8.5 mtrs.
Rotor speed (synchronic)	45.0/35.5 r.p.m.
Generator speed	1000 r.p.m.
Gear ratio	1:22.2
Generator name plate	90/19 kW
Wind vane	Electronic Vestas

6. Power curve for Vestas 17/75 kW

Estimated from measurements on Vestas 17/75 kW
Rotor diameter 17 m
Rotor speed 35.5/45 rpm
Tip pitch ÷ 1°
Air density 1.225 kg/m³



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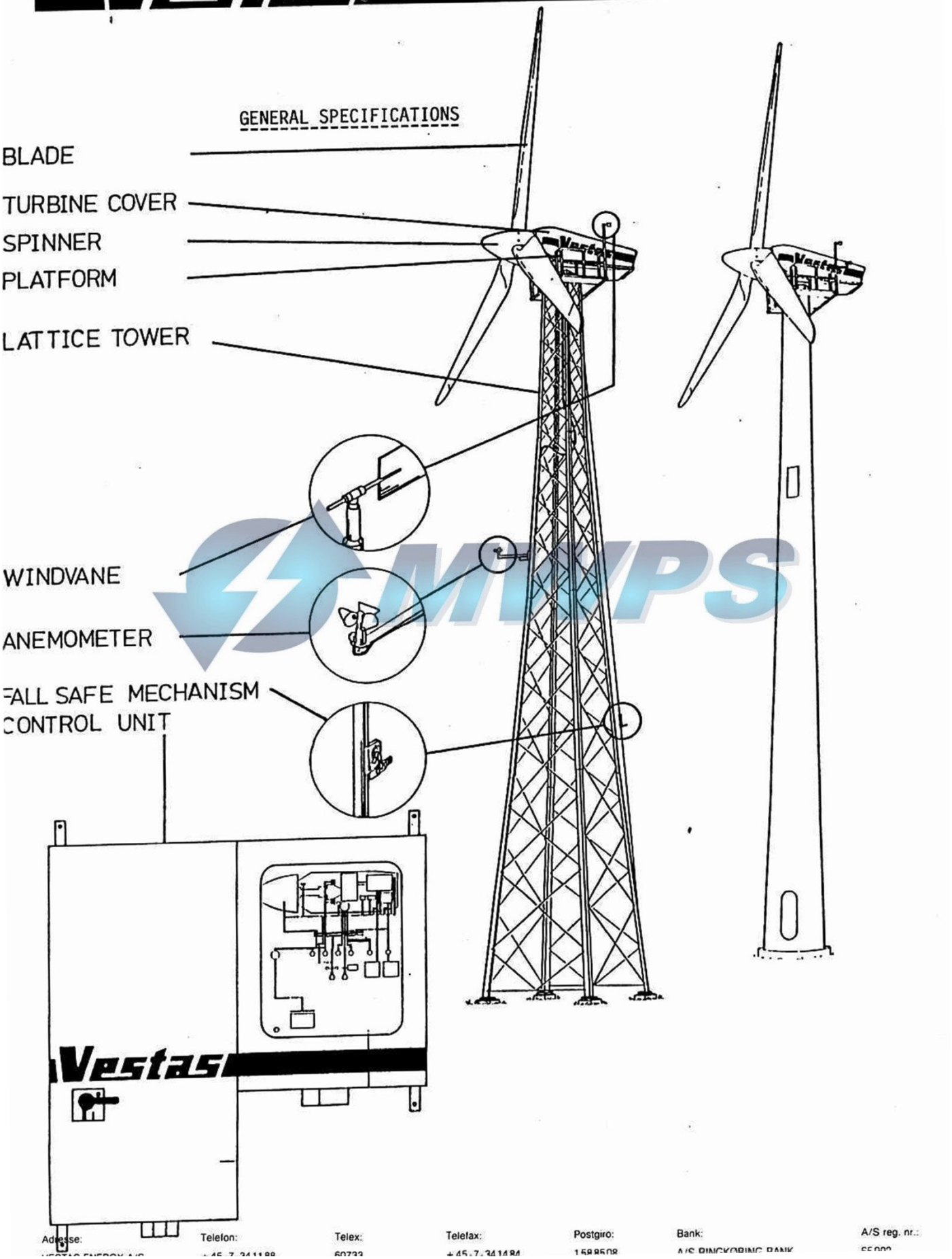
GENERAL SPECIFICATIONS



Adresse: | Telefon: | Telex: | Telefax: | Postgiro: | Bank: | A/S reg. nr.:
VESTAS ENERGY A/S | +45 7 341188 | 60733 | +45 7 341484 | 158 8508 | A/S RINGKØBING BANK | 65 002

Vestas

2. General specifications

2.1. Description of Vestas V17-90 kW wind turbine

2.2. The Vestas V17-90 kW is a horizontal-axis wind turbine with a three-bladed, fixed pitch rotor that operates upwind of the tower.

The blades are stall regulated and the rotor itself turns at one of two different low speeds, depending on which generator is in operation at the time.

The speed increasing gearbox is of the parallel shaft type and the twin-generator system consists of one large and one small generator, connected by a V-belt drive transmission element. Both generators are asynchronous, i.e. run at a "constant" r.p.m., and designed for direct connection to the utility network at 480-500V AC 60 Hz.

The wind turbine is also equipped with an active electric drive yawing system and a control unit that is based on either electro-mechanical relays or microprocessor chips.

The V17-90 can be fitted on to either the VESTAS free standing lattice tower or the VESTAS tubular tower.

2.3. Specifications

2.3.1. Rotor

Diameter:	17.0 m (55.8 ft.)
Rotational speed (synchronous):	50.2 r.p.m.
	39.5 r.p.m.
Rotational speed (75 kW):	50.9 r.p.m.
Rotational direction:	Clockwise
Orientation:	Upwind
Number of blades:	3, stall regulated
Aerodynamic brakes:	Pivotable tips

2.3.2. Blades

Material:	Reinforced polyester fibreglas
Airfoil:	NACA 44
Swept area:	227 M² (2442 ft²)
Tip brakes:	Centrifugal force activated

2.3.3. Tower

Type:	Lattice tower
Height:	23.4 m (76.77 ft)
Weight excl. foundation bolts:	4.250 kg (9370 Lbs)
Surface:	Hot-galvanized

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2.3.4. Tower

Type:	Tubular tower
Height:	22.5 m (73.82 ft)
Weight:	5.600 kg (12.345 Lbs)
Surface:	Hot-galvanized and painted

2.3.5. Generators

Type:	Induction generator
Main generator:	110 kW
Small generator:	22 kW
Voltage:	480 V AC
Rotational speed (synchronous):	1200 r.p.m.
Frequency:	60 Hz

2.3.6. Gearbox

Type:	2 stage increasing parallel shafts
Gear ratio:	1:23.9
Rated power:	75 kW (safety factor 2)

2.3.7. Yawing system

Type:	Active yaw
Control:	Windvane (electronic)
Yawing speed:	51-55 degrees/min.

2.3.8. Operational data

Cut-in windspeed:	3.3 m/s (7.4 mph) ± 10%
Rated windspeed (75 kW):	16.8 m/s (37.6 mph)
Cut-off windspeed:	28 m/s (62 mph) ± 5%. (For more than 5 sek.)
Survival windspeed:	50 m/s (112.0 mph) (Measured at hub height).

2.3.9. Weight

		US
Lattice tower excl. foundation bolts:	4250 kg	9370 Lbs
Turbine and rotor excl. tower and control unit:	6380 kg	14065 Lbs
Total weight:	10630 kg	23435 Lbs
Tubular tower excl. foundation bolts:	5600 kg	12345 Lbs
Turbine and rotor excl. tower and control unit:	6380 kg	15065 Lbs
Total weight:	11980 kg	26410 Lbs

Vestas

General specifications

2.4.0. Components of the Vestas turbine V17-75

2.4.1. Speed increasing gearbox

Nominal power:	180 kW
Rated power:	90 kW
Safety factor (reff. 75 kW):	2.0
Speed ratio:	1:23.9
Type:	2 stage Helical gear
Low speed shaft:	Hollowshaft
Shaft diameter, high speed shaft:	60 mm (2.36 inch)
Manufacturer/Type:	Flender type SZAK 1320
Volume of oil:	29 l (7.66 US gal.)
Weight of gearbox:	800 kg (1764 Lbs)
or	
Manufacturer/Type:	Hansen RTF6
Volume of oil:	40 l (10.57 US gal)
Weight of gearbox:	700 kg (1543 Lbs)

2.4.2. Yaw-gear

Type:	Worm and wheel, double
Manufacturer/Ratio:	BJ - VESTAS 1:900
or	
Manufacturer/Ratio:	BONFIGLIOLI 1:840

2.4.3. Yaw-motor

Type:	Induction motor
Rotation speed:	1710 r.p.m.
Rated power:	0.55 kW
Voltage:	400 V AC
Manufaturer:	GRUNDFOS MG 71B4-14F85

2.4.4. Generators

Main generator

Rated power: at	110 kW
Voltage:	480 V AC
Frequency:	60 Hz
Class of isolation:	F (windings)

Main generator (cont)	
Rotational speed (75 kW):	1218 r.p.m.
Shaft diameter:	80 mm (3.15 inch)
Shaft diameter:	70 mm (2.76 inch)
Consumed reactive power:	67.9 kVAr
Mounted capasitor:	30 kVAr
Manufaturer/Type:	ASEA MBM 315 MA or corresponding product

2.4.5. Small generator

Rated power:	22 kW
at	
Voltage:	480 V AC
Frequency:	60 Hz
Class of isolation:	F (windings)
Rotational speed (15 kW):	1220 r.p.m.
Shaft diameter:	55 mm (2.16 inch)
Consumed reactive power:	20.5 kVAr
Mounted capasitor:	10 kVAr
Manufaturer/Type:	ASEA MBT 200 LA or MBT 200 or corresponding product

2.4.6. V-belt drive between generators

Grooved pulleys:	Nominex diameter 400/315 mm
Ratio:	1.27
Manufacturer (pulleys):	IPL
Number of belts (V-shaped):	3 SPB 2360

2.4.7. Rotor shaft assembly

Shaft dimensions:		ø 160/150 x 2065 mm
Distance between bearings:		780 mm
Type of bearings:	Front:	SKF 22243 CC/W33
	Rear:	SKF 22230 CC/W33
Housing and shaft:		VESTAS
Hub-connection:		Forged, part of the shaft
Propeller bracket:		VESTAS
Brake disc:		VESTAS (nodular cast iron/ductile iron)
Maximum torque:		21.4 kNm
Safety torque (braking):		43.0 kNm (nominal value)

2.4.8. Propeller (3 blades)

Material:		reinforced polyester fiberglass with nodular cast iron root
Connection to bracket:		Flange
Airfoil:		NACA 44
Chord lenght:	Tip:	500 mm at R=8500 mm
	Root:	1100 mm at R=1750 mm
Overall lenght of blades:		8200 mm
Tipbrake assembly:		VESTAS-type
Blade manufacturer/Type:		VESTAS

2.4.9. Hydraulic motor

Frequency:	60 Hz
Rotation speed:	1590 r.p.m.
Voltage:	480 V AC
Manufacturer/Type:	Bauknecht motor type FP14

2.4.10. Hydraulic unit

Pump capacity:	0.67 l/min
Max. pressure:	330 bar
Brake pressure:	140-150 bar
Pump manufacturer:	HAWE
Solenoid valve:	HAWE BWN1F
Accumulator:	1.4 l
Pressure load:	100 bar
Manufacturer:	BOSCH

2.4.11. Brake

Disc diameter:	700 mm
Braking on low-speed shaft:	Nodular cast iron/ ductile iron
Calipers:	3 pc. hydraulically activated
Manufacturer:	BREMBO

2.4.12. Transmission joint

Type:	Cardan joint
Max. torque:	8000 Nm
Manufacturer/Type:	Centaflex CF-A-140-G-2

2.4.13. Tower

Lattice tower

Type:	Lattice mast, bolted, angle iron elements, 3 sections
Height:	23.4 m
Manufacturer/Type:	Carl C. Jensen VESTAS 23.4 m

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Tubular tower

Type:	Tubular tower, bolted 3 sections
Height:	22.5 m
Manufacturer/Type:	VL-Stål VESTAS 22.5 m

2.4.14. Control unit

Relay based control unit	Vestas design based on electro-mecanical relays
Micro processor based control unit	Vestas design based on micro processes

2.4.15. Anemometer

Vestas design Type:	Optoelectrical

2.4.16. Windvane

Vestas design	
Type:	Optoelectrical

VESTAS reserves the right to change any of the above mentioned data specifications at any time.

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Weight for V17 parts	KG	US
Spinner	30 kg	66.1 Lbs
Blades, set of 3 ± 25 kg. pr. blade	1470 -	3240.7 -
Blade hub + fitting	309 -	681.2 -
Shaft and bearing arrangement	799 kg	1761.5 Lbs
Main shaft	378 -	833.3 -
Bearing house	180 -	396.8 -
Bearing	41 -	90.4 -
End cap and rings	35 -	77.2 -
Grease and bolts	7 -	15.4 -
Brake disc	120 -	264.6 -
Shrink disc	38 -	83.8 -
Gearbox with coupling flange incl. oil		
Flender	872 kg	1922.4 Lbs
Hansen	802 -	1768.1 -
Shrinkelement gear	35 kg	77.2 Lbs
Hydraulic unit	27 -	59.5 -
Consol for brake calipre	40 -	88.2 -
Brake calipre set of 3	18 -	39.7 -
U-steel for moment plate	3 -	6.6 -
Yaw wheel incl. fitting for tower	392 -	864.2 -
Yawing gear BJ-gear	61 -	134.5 -
Generator Asea MBM 315 MA incl. 3 m cable		
Coupling flange, V-belt pulley	720 -	1587.3 -
Generator Asea M 200 LA incl V-belt pulley	205 -	452.0 -
Machine foundation, ready for mounting	985 -	2171.5 -
Rubber coupling	19 -	41.9 -
Machine cover incl. frame	135 -	297.6 -
Screws, nuts etc.	75 -	165.4 -
Balconies set of 2	125 -	275.6 -
Controller (micro)	125 -	275.6 -
Controller (relay)	125 -	275.6 -

Tower

Tubular tower V17 (VL-stål)	5600 kg	12345.7 Lbs
Export tower V17	4250 -	9369.5 -
Yawing plate and towertop	392 -	864.2 -
Foundation bolts for tubular tower	300 -	661.4 -
Foundation bolts for lattice tower	210 -	463.0 -

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Installation

Terrain

If the terrain within a 100 m radius of the wind turbine has a slope of more than 20%, the cut-off wind velocity must be decreased. Please contact Vestas for furhter details.

Climatic conditions

The Vestas wind turbine is designed for an ambient temperature range from -10° C to +40° C. Outside this range it will be necessary to decrease the cut-off wind velocity or to stop the wind turbine. The wind turbine is designed for a mean air density of 1.23 kg/m³. The operational data in section 2.7 are given at this air density. If the mean air density differs more than ± 5 % from this value, it may be necessary to change the specifications of the wind turbine. Within the 5 % tolerance, only pitch angle will be changed. For wind turbines outside the ± 5 % tolerance, please contact Vestas for further information.

Main connection

Intermittent or rapid fluctuations of utility grid frequencies may cause serious damage to the wind turbine. Steady variations within ± 1 Hz are acceptable. The voltage may have a variation of ± 20 V AC. When dimensioning windfarms the reactive power must be taken in consideration. In order to avoid the problems associated with large voltage fluctuations the low voltage grid should be able to consume the turbine's production. For wind parks, the grid's stiffness and consumption patterns should be the basis for the specific dimensions.

Various topics

For long-distance transportation that subjects the wind turbine to prolonged vibrations, it may be necessary to take special precautions to avoid damage to the bearings. These precautions are usually only necessary with respect to transportation by rail.

As an industrial machine, a wind turbine should not be installed too close to populated areas where possible noise and safety issues could present a problem. For this reason, we recommend that our wind turbines to be installed at least 200 m away from homes and public areas and unauthorized persons are kept at least 100 m away from the turbine.

If the wind turbine is to be located in an area that is prone to lightning, it may be necessary to take precautions to avoid possible damage to the wind turbine.

The wind turbine is corrosion protected for most environmental conditions. However, if the wind turbine is to be installed in a high-corrosion environment, i.e. very close to the sea or polluted air, it may necessary to equip the wind turbine with additional corrosion protection.

Vestas

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Safety regulations for operator & serviceman

3.0 SECURITY REGULATIONS (IMPORTANT !!!)

A main connected wind turbine will naturally contain some moments of danger if it is evaded thoughtlessly. Therefore the following security regulations must be observed.

3.1 STAY AND TRAFFIC AT THE TURBINE

Do not stay within a radius of 25 mtrs. from the tubine if it is not necessary.

If you have to inspect the turbine form the ground do not stay in the propeller plane but observe the propeller from in front (wind side).

Take care that children do not stay or play on or at the turbine. If necessary build a fence around the foundation. Entry to the control of the turbine must bu locked so that intruders cannot "operate" with the tubine.

3.2 CONTROL UNIT AND SWITCH BOARD ARRANGEMENT

WARNING: HIGH VOLTAGE!

The wind turbine control contains wirings with high voltage and the covers to the switchboards must not be opened. If it is necessary to open the covers to the control, this must be done by ab authorized person or serviceman. The covers which are sealed can be opned by the authorized serviceman after having consulted Vestas´ service department but if the seal is broken without Vestas´ permission the guarantee will repeal.

Adresse	Telefon:	Telex	Telefax	Postgiro	Bank	A/S reg. nr.
VESTAS ENERGY A/S POSTBOX 42 DK 6940 LEM DENMARK	+ 45 7 341188	60733 VESTAS DK	+ 45 7 341484	1588508	A/S RINGKOBING BANK 7650 2100 76 4 DEN DANSKE BANK 3403 14700 1	65903

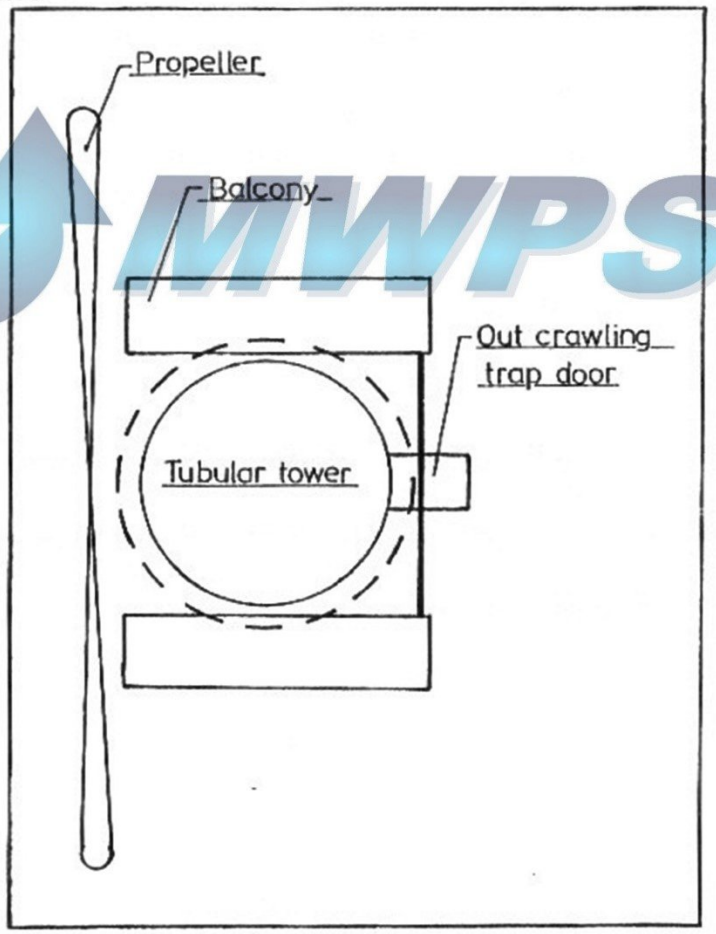
Safety regulations for operator & serviceman

3.3 Inspection of the turbine machinery

When inspecting the turbine machinery the following procedure must be followed:

A. The key in the controller is turned to the left (to position 0), which causes braking. Turn the key back to position 1, which causes 90^0 yawing of the turbine, out of the wind.

B. If it is a tubular tower, it is necessary to yaw the turbine manually, so the propeller is standing oppesite the out crawling trap door.



Adresse
VESTAS ENERGY A/S
POSTBOX 42
DK 6940 LEM
DENMARK

Telefon
+45-7-341188

Telex
60733
VESTAS DK

Telefax
+45-7-341484

Postgiro
1586508

Bank
A/S RINGKØBING BANK
7650 20076 4
DEN DANSKE BANK
3403 14701 1

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Safety regulations for operator & serviceman

B. There is no special position for a turbine on a lattice tower. The operator/serviceman should just could entry the balcony, without loosen the safety-line.

The person, who crawls up the turbine shall have the key in his pocket. (The key can be taken out in both position 0 and 1).

C. The main switch on the switchboard is cut off.

D. You can now crawl up in the turbine, but remember:

- Put on footwear which is suitable for climbing in the tower. Always use tight-fitting footwear with rubber soles (rubber shoes or boots) never clogs.
- Put on your safety - belt with the safety line (the short one) inserted the safety catch.
  See photo. (use only approved equipment).
- Put on your hard hat.
- See that none is staying under the turbine when you start climbing.
- Take your time and move carefully in the tower.

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Safety regulations for operator & serviceman

E. When you have reached one of the platforms you hook the long safety line to the platform before you dismount the short one from the safety catch.

When standing on the platform you open the safety lock of the cover in one of the sides and then in the other. Now the cover can be opened. Remember to be fastened to the safety line all the time also when you move from one platform to another.

F. While working on the platform you are fastened to the nacelle or to the guard rail with at least one safety line.

G. Do not let an assistant on the ground start the turbine.

H. If you bring tools, lubricants etc. keep this in a bag tied to your safety belt.

I. Take still care that no one is staying under the turbine while you are working in the nacelle. (Even a small wrench is highly dangerous when falling from a height of 23 mtrs.).

J. After inspection, lubrication etc. you close the safety locks for the machine cover. Be sure that you have brought all tools with you before you start the descent.

K. Extra caution must be shown when climbing in the mast when it is wet or covered with ice.

L. If the blades have been or are iced up it is involved with great danger to walk under or near the propeller. When the ice has melted and the turbine is restarted the rotor plane is turned out of the operator's Position before the turbine is started.

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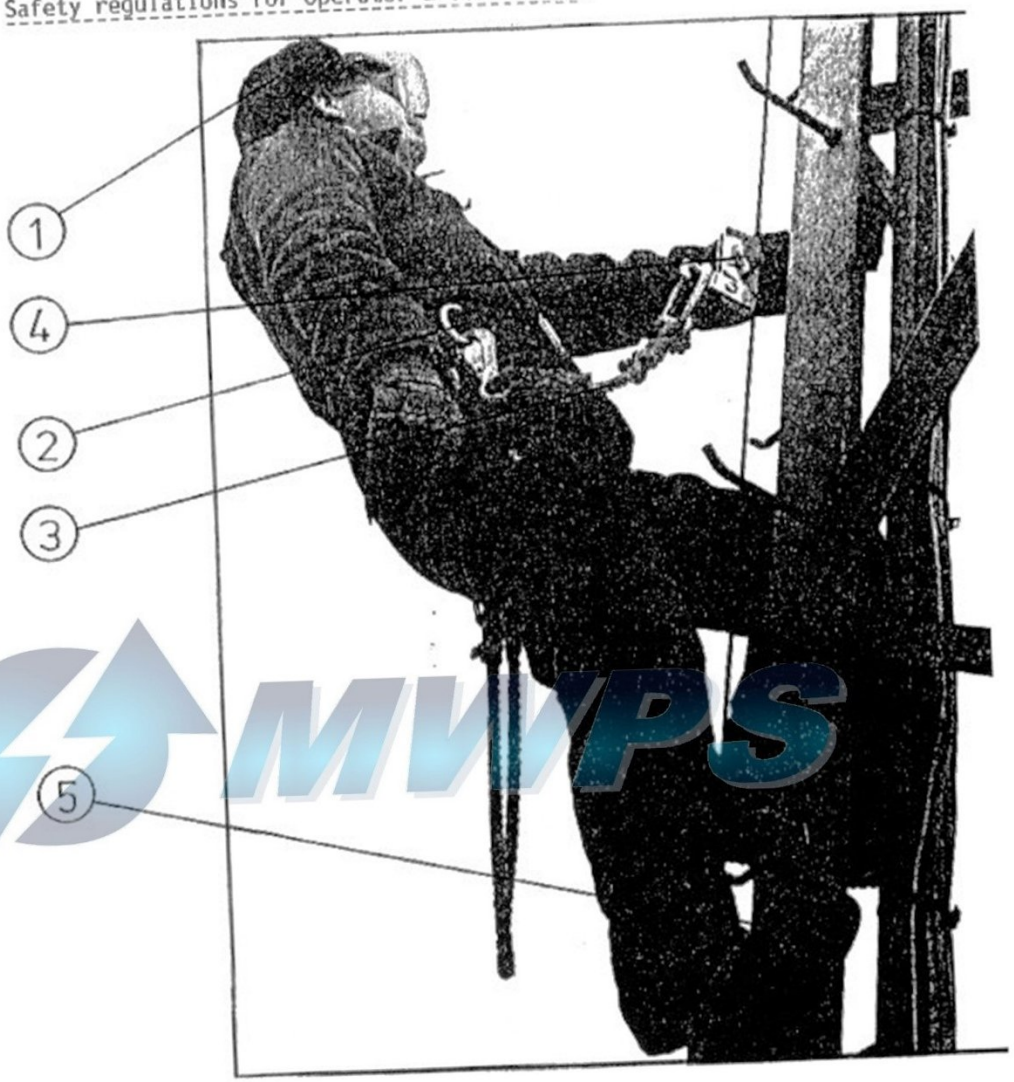

1 HARD HAT
2 SAFETY BELT
3 SAFETY LINE
4 SAFETY CATCH
5 SHOOES OR BOOTS WITH RUBBER SOLES

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MICRO

Vestas

4. FUNCTIONS OF VESTAS V17-75/90 KW WIND TURBINE WITH MICRO PROCESSOR BASED CONTROL UNIT

4.1. The turbine function is in short described in the following:
Upstart, procedure and method of working.

In pos. 0, the computer current supply and the contactor control current are disconnected, but the power unit is still connected to the grid.

4.1.1. The key is turned to pos. 1:
The computer starts operating. At first the computer checks the grid, 10 sec. later the display is switched on.
The display will look as follows:

RMP INIT BR WIND SPEED M m kW

4.1.2. Push the brake button. The solenoid valve is activated, and the brake is released.

4.1.3. Providing the windspeed is above 3m/sec., or the turbine produces, the turbine yaws into the wind - controlled by the wind vane. This is indicated by the arrows on the display.

RMP INIT BR WIND SPEED M m kW

1.4. At a windspeed of sufficiently high strengh, the propeller will start operating and increase in speed. In the beginning the speed increaces slowly, but at a certain number of revolutions, it will begin to increase faster, as the aerodynamic profiles are not efficient before a certain speed has been obtained. For the same reason the necessary startwind must be higher than the windspeed necessary to keep the propeller rotating and producing. For example, a propeller in operation can keep rotating down to a windspeed of app. 3m/sec., but it is necessary with gusts of about 5-6 m/sec. to start up a turbine. To meet this condition, the turbine is equipped with an automatic wind up-start, which causes the small generator to drive the propeller.
The generator cuts in by means of the thyrisistors, which ensures a smooth up-start, protecting the V-belts and the gear. If the windspeed is above 3,9 m/sec., the turbine will automatically start up.
The 55kw turbine consumes 18kw during up-start. The 75kw turbine consumes 30kw. The above mentioned fuciton has an advantage if there is a constant windspeed of about 4-6 m/sec.

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4.1.5. If there is enough windspeed to operate the small generator, the propeller will increase in speed until the number of revolutions, corresponding to the gearing and the transmission ratio for the synchronous number of revolutions on the small generator are reached.

4.1.6. If the wind speed increases slowly, the computer will disconnect. Providing the windspeed is below 6,0 m/sec., the computer connects the small generator and the hour counter for the small generator begins operating.
If the windspeed is above 6,0 m/sec., the turbine is not connected to the small generator, but directly to the main generator.
If the wind speed increases slowly, the computer will disconnect the small generator when max. production has been measured for 12 seconds.
The turbine freewheels until it accomplishes the necessary number of rotations (1000 rpm), inabling it to connect the main generator, and start-up the hour counter for the main generator.

4.1.7. The main generator produces wind speeds, which lie between the small generators rated output, and up to the maximum production capacity, which is adjusted to 23m/sec. on the anemometer.

4.1.8. If the wind speed decreases down to app. 1 kW, while the turbine operates on the main generator, it will disconnect the main generator and connect the small generator to the grid, causing the wind turbine to brake to the number of revolutions corresponding to the production output of the small generator.

4.1.9. If the small generator produces, and the wind speed decreases to a value corresponding to the small generators minimum production (app. 1 kW production), the small generator is then disconnected from the grid, and the propellers operate freely in the wind.

4.1.10. If the wind decreases down to app. 2,5 m/sec., automatic yawing will stop, perhaps causing the propeller to stop. When the wind speed increases to above 3 m/sec., it will automatically connect the controller and the wind vanes control of the yaw motor will keep on turning the propeller up against the wind.

4.1.11. One of the reasons why the automatic system disconnects at low wind speeds, is because the wind vane is very unstable at low wind speeds, and, as the wind turbine isn't capable of producing, one saves using yaw motor energy, and prevents unnecessary cable-untwist.

4.1.12. In this section it aught to be mentioned, that all values are mean values, which means that short period diviations will not result in repectively diconnection or connection of the wind vane.

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RELAY
MWPS

4.

FUNCTION OF VESTAS V17/90 KW WIND TURBINE WITH RELAY BASED CONTROL UNIT

4.0

The operation of the turbine is briefly described in the following and elaborated later under the operating instruction:

4.1

STARTING UP PROCEDURE
Provided that none of the faulty functions are in force and that the turbine is braked with the key on 0 the starting up of the turbine is done as follows:

A. The key is turned to the right on 1 and there is light in the lamps: BRAKING AUF: 98° YAWING; LINEFAIL RESET; and the YAWING CCW lamp
B. RESET is pressed in and the light disappears in all the lamps.
C. If the wind is over 3 m/s the turbine will yaw into the wind and "automatic operation" will give yellow light. Light in AUTOMATIC OPERATION indicates that the wind vane is active and that the turbine is ready for service.

FUNCTION OF TURBINE WHEN STARTING-UP AND OPERATING

4.2. When the starting-up procedure has been carried out according to items A-C the following will take place in the nacelle:

4.2.1. There will be a voltage on the solenoid valve in the braking system and the disk brake is loosened and is hold in a loosened position. The propeller can rotate freely.

4.2.2. Provided that the wind is more than 3.0 m/s the turbine will turn into the wind controlled by the wind vane. The yawing direction is indicated by the arrows ↶ ↷

4.2.3. If the wind has a sufficiently large force the propeller will start rotating and increasing its speed. At first the speed is increased slowly but at a certain r.p.m. the speed is increased quicker as the wings (having aerodynamic profiles) first will be effective when they rotate with a certain speed.

4.2.4. As an example a given propeller can keep rotating right down to about 3.0 m/s in operation where as gusts of the size 5-6 m/s are needed in order to start a stopped propeller due to inertia and friction in transmission.

4.2.5. To remedy this situation the turbine is equipped with MANUEL STARTING-UP which works when the propeller is driven by the small generator which works as a motor when pressing on MANUAL START.
This operation can especially be used profitably if the wind has a constant character in an area below about 5-6 m/s.

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4.2.6. If there is enough wind for operation of the small generator the propeller will increase its speed until it reaches the r.p.m. which with the given gearing (gear and V-belt gearing) corresponds to the synchronous r.p.m. of the small generator 1035 RAM. The control unit will now connect the generator to the utility and the turbine will give the produced electric energy to the utility. This is indicated by means of light in the lamp SMALL GEN. and the hour counter runs.

4.2.7. If there is still enough wind to operation of the main generator, the turbine will only produce briefly on the small generator (corresponding to the installed time lag which is to prevent too frequent changing overs) and then connect to the main generator.

4.2.8. This take place when cutting out the small generator. After this the propeller runs freely and increases its speed until it reaches the r.p.m. which with the fixed gearing (the gear itself) corresponds to the r.p.m. on the main generator (1035 RPM). Now the main generator is connected to the utility and the turbine gives the produced electric energy to the utility. This is indicated by means of light in the lamp MAIN GEN. and the hour counter runs.

4.2.9. The turbine produces on the main generator in wind speeds from one that corresponds to the rated out-put of the small generator up to the maximum permissible wind speed of the production which is adjusted to the anemometer. The anemometer sees to braking of the turbine if the cut off wind speed is reached. (The cutt off wind speed is about 26 m/s).

4.2.10. If the turbine produces on the main generator and the wind speed falls so much that the given power falls to near 0 the main generator will declutch with a certain time laf and the small generator is connected to the utility by which the turbine is braked down to a number of revolutions corresponding to the production on the small generator.

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4.2.11. If the turbine produces on the small generator and the wind speed falls below the speed that corresponds to the minimum production of the small generator (i.e. 0-production) the small generator will declutch from the utility with a certain time lag and the propeller runs freely in the wind.

4.2.12. Further falling wind speed will cause that the propeller will stop but the turbine is still operating automatically and will start rotating and producing again when the wind reaches relevant speeds.

4.2.13. The wind vane control of the yawing motor which turns the propeller plane up in the wind takes place constantly (when AUTOMATIC OPERATION gives out light) irrespective of the fact whether the generators are connected or not.
However, the wind vane is connected through a signal from the anemometer when the wind falls below about 2.5 m/s. It is reconnected at a higher wind speed about 3.0 m/s.
This declutch is carried out in order to prevent cable twisting at low wind speeds where the wind speed is insuffucient to hold the wind vane constant.

4.2.14. All the mentioned wind speeds which have relation to the cut in and cut out operations are sampled values i.e. that short excesses of the given limits do not cause respectively cut in or cut out of the wind vane. The wind vane corrections of the propeller orientations are indicated by means of light in the lamps and yawing direction ↙ ↘

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4.3. MANUAL BRAKING

The turbine is braked manually by turning the key to 0. After about 5 sec. the key is turned once more this time to 1. The 90^{0}-yawing function is cut in and it sees that the propeller plane is turned 90^{0} out of the wind.
The wind vane will still see that the propeller plane is turned in this position proportional to the wind direction permanently. Therefore also if the wind changes direction. By turning the key switch off to 0 repeatedly and then to 1 the turbine will yaw 90^{0} (in 90 sec.) every time (counter clockwise). The wind vane will, however, always yaw the turbine back in a position 90^{0} on the wind direction (when the turbine is braked).
This security procedure can be used if the turbine is left braked and will set in itself if the turbine brakes itself because of faults. In this situation there will be light in the lamps BRAKING, LINE, YAWING and RESET after manual braking.
A braking because of faults one or more of the faults indication lamps will light instead of LINE.

4.4. MANUAL YAWING

The yawing takes place by pressing the buttons respectively ← and → which have an indication function beside the contact function.

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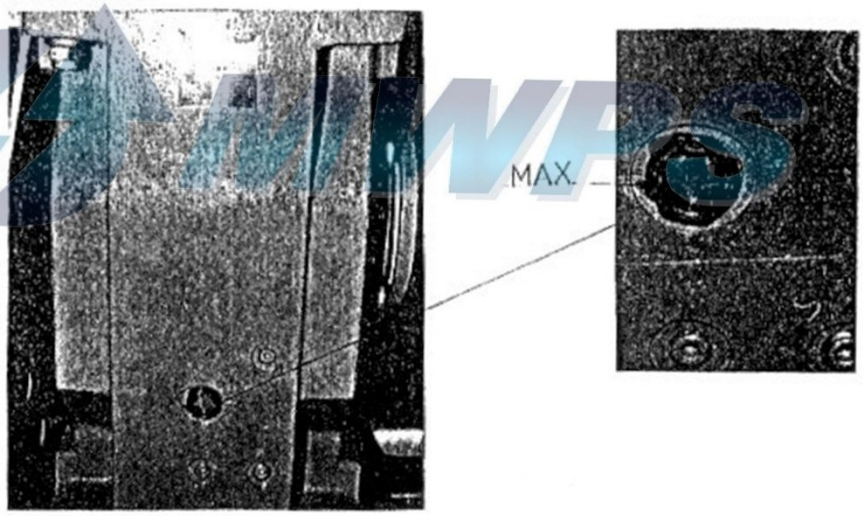
5.1. Check of oil level on gearbox:

Correct oil level in the gearbox is of vital importance. The gears and bearings are oil lubricated.

A scraper plate on each side of the gear wheel collects oil and channels it to oil collectors on both housing sides. From there the oil is destributed through bores in the housing and channels in the covers to the bearings of the low speed and high speed shaft. The bearings of the intermediate shaft are lubricated directly by contact with the oil bath.

The oil level must be as close to the middle of the sight glass as possible.



Checking the oil level, must ne done every third month or every time there is lubrication or maintenance of the turbine. If the oil level is below the middle (max) of the oil level sight glass, it is necessary to refill the gearbox.

Note: If the oil is very cold, the oil level may be down 2 mm below max. If the oil is very hot, the oil level might be a little bit above max.

5.1.2. Maintenance of gearbox

Maintenance operations are limited to oil level, and regular oil change.(See oil change gearbox).

5.1.3. Breather control

To prevent pressure build-up, a breather is installed on the upper side of the housing. Take care and check regularly that this breather does not become clogged.

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5.2.1. Oil change on gearbox

Oil can be left in a gearbox for two years of operation, in case for all V17 gearunits filled with ISO VG 220. And if the ambiant temperature is between ± 10 - + 40 deg. C (14-54 deg. F).

After the 2 years period the oil have to be changed.

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5.2.2 Used for oil change:

Closed oil tins of good quality, is used when hoisting the oil from and to the turbine.
Wrench: 36 mm is used to dismantle the oil plug where the new oil filled through (only for Flender gearbox). On the Hansen gearbox the dismantle of the oil plug can be done by hand.
Monkey wrench is used to dismantle the drain cock when removing the oil.
Funnel is used for oil filling.
Oilcan is used when draining the oil from the gearbox.
Rags is used for cleaning and removal for oil waste.

Removal of oil:

The oil is removed from the gearbox by opening the drain cock.

Hansen

Flender

Use the oil can and the closed oil tins to collect the old oil.

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5.2.3 Filling of oil

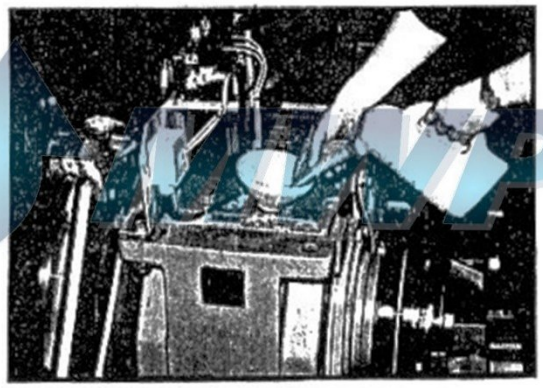
The drain cock is closed and the new oil is filled through the filling hole, in the inspection cover, where the funnel is used.

Oil quality:

See next page 5.2.4.

Quantity:

Hansen gear about 39 l.
Flender gear about 28,5 l.



Note: The oil quantity shown on the name plate is only a guide value. The exact oil level is to the middle of the oil sight glass.

Cleaning:

When the oil change is done, the gearbox and foundation has to be cleaned for oil waste. The drain cock has to be checked for leakage.

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Oil change gearbox

Alternative oil qualities

Esso:	Spartan EP 220
Mobil:	Mobil gear 630
Shell:	Omala Oil 220
Texaco:	Meropa 220
BP:	Energol GR-XP 220

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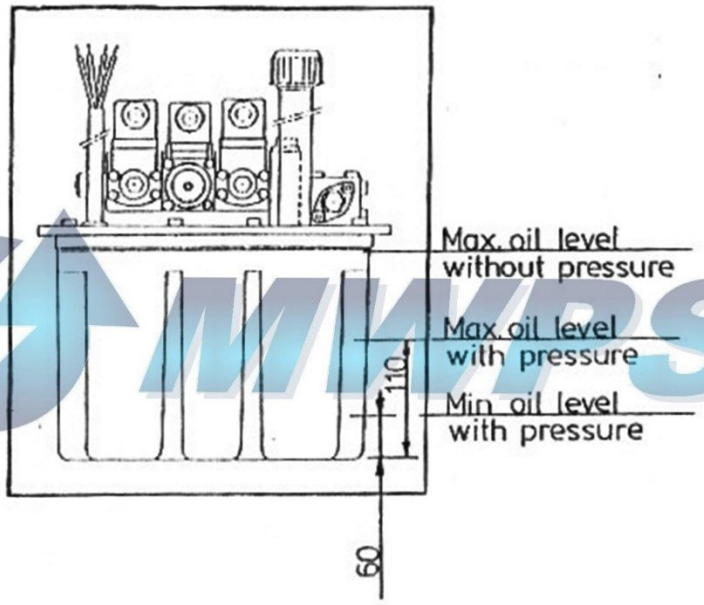
5.3 Oil level check brake system

The oil level can only be checked visual. Every time lubrication or maintenance is done on the turbine, the oil level on the brake system have to be checked.



Refilling of oil must be done if the oil level is not at the same level as "max oil level with pressure".

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5.4.1 Oil change brakesystem

The oil in a Hawe brakesystem has to be changed every 5 years.

Every time lubrication or maintenance is done on the turbine, there have to be made a visual check for condensation water in the bottom of the oiltank.

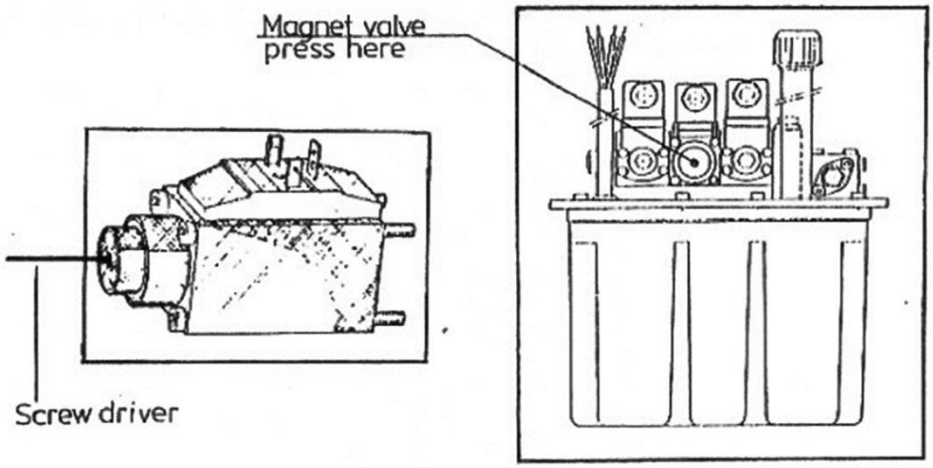
The condensation water is caused by termal fluctuations.

If there is any condensation water in the oil tank the oil has to be changed.

If changing the oil is caused by condensation water the whole brake unit has to be dismantled.

Before dismantle the brakeunit

Release the brakepressure. By using a small screw-driver, it is possible to open the magnet valve and release the pressure.
Press on the middle of the valve, and it will open.



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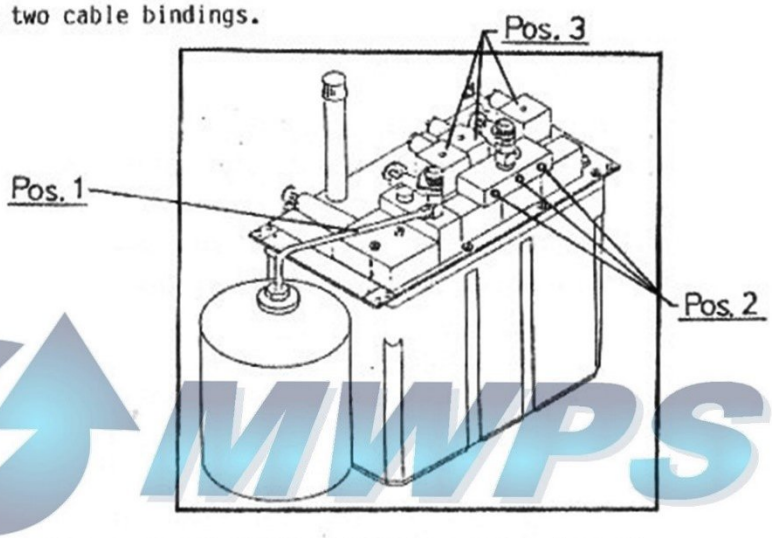
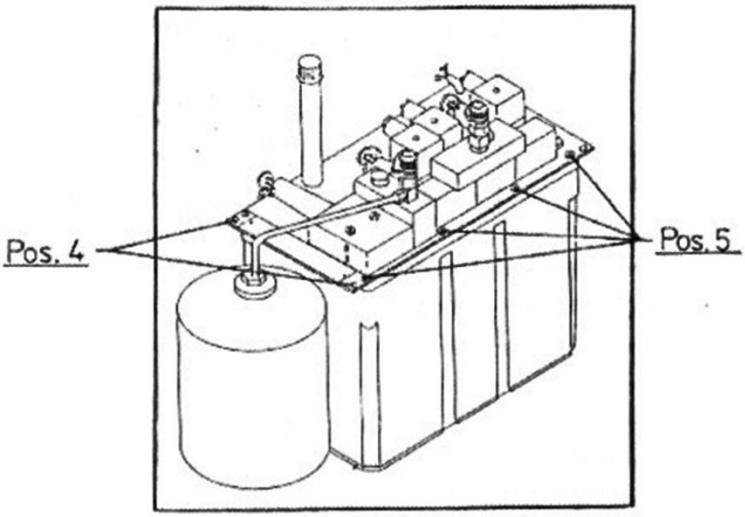
5.4.2 Dismantle the hydraulic pipe, comming from the accumulator (pos 1).
Dismantle the hydraulic hoses from the connection block (pos 2).

Dismantle the 3 plugs on the two pressureswitches and on the magnet valve (pos 3).

Cut the two cable bindings.



Now dismantle the brakeunit from the brakeconsol (pos 4).



Take down the brakeunit, and dismantle the oil tank (pos 5).

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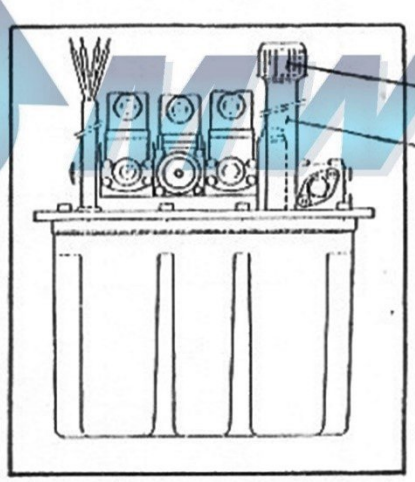
5.4.3 Drain the tank for oil and water in a empty can. Clean the oil tank.

Mount the oil tank back on the brakeunit.
Mount the brakeunit back on the brakeconsol, where the hydraulic pipe, hoses and plugs are connected again.

Refill the brakesystem

Dismantle the bleeding filtre (pos 1).
Use a funnel to refill the oiltank through the pipe (pos. 2).

Fill up the oil tank, but only to the line.
After refilling, see bleeding brakesystem



Oil quality: see next page
Oil quantity: approx. 2 liter.

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5.4.4 Oil change brake system

Alternative oil qualities:

Esso:	Univis HP 22
Mobil:	DTE 22
Shell:	Tellus oil S 22
Texaco:	Rando HDA 22
BP:	Bartran HV 22

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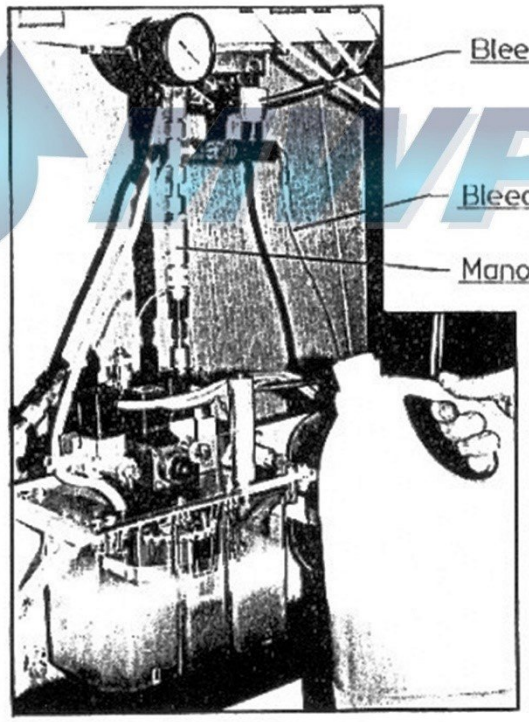
5.4.5 Oil change brake system

If it's a regular oil change, it is possible to pump the oil out of the system. It can be done with the manometer, where the bleeding hose is placed in an empty oil can. When the manometer is mounted, open the bleeding screw, and the oil will be pumped out of the system and into the oil can.

After refilling with new oil, see "bleeding brake system".



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5.5.1 Bleeding brakesystem

No air must be allowed in the brake system under any circumstances. If there is any air in the brake system, braking capasity will be reduced severely, and the brake system will be unable to stop the turbine when it is necessary.

Procedure

Turn the keyswitch on the control panel to 0 and then back to 1, which causes braking and yawing. There has to be pressure on the brake system when the bleeding is made.
Each brake caliper has a bleeding screw. The top caliper has two.

Put a 5 mm hose on the bleeding screw (pos. 1). Put the other end of the hose in an empty oil can, where the wasted oil will be collected.

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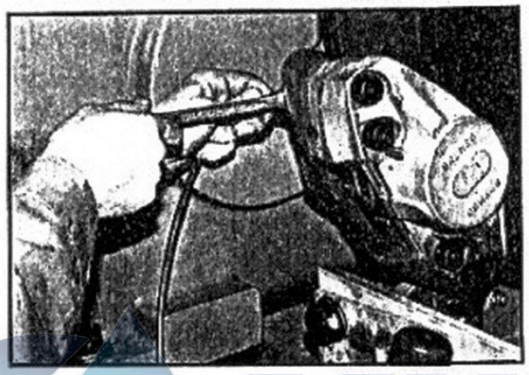
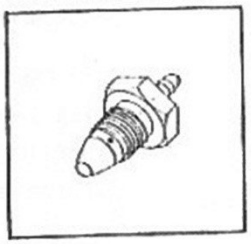
5.5.2 Bleeding brake system

Loosen the bleeding screw with a ring key, not dismantle (pos. 1).

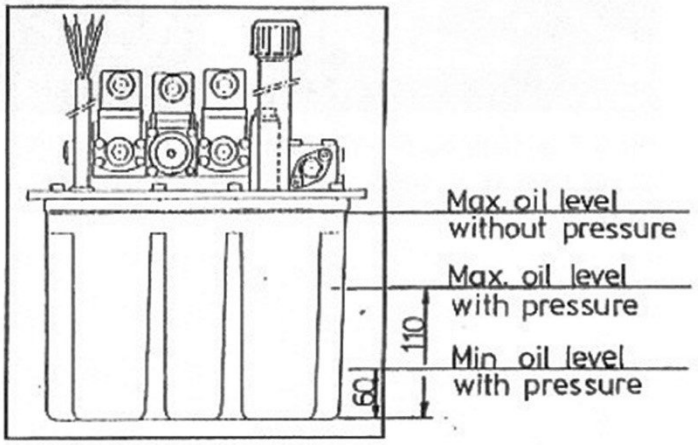
Pos. 1



Bleeding screw



The hose has to be drained for old oil before the air is comming out.
Keep the bleeding screw open, until all airbubbles has come out.
When it's only clean oil comming out, tighten up the bleeding screw again.
This procedure is repeated on the other calipres.
If the oil level is not up to "max oil level with pressure", it is necessary to refill the oil tank up to "max oil level with pressure".



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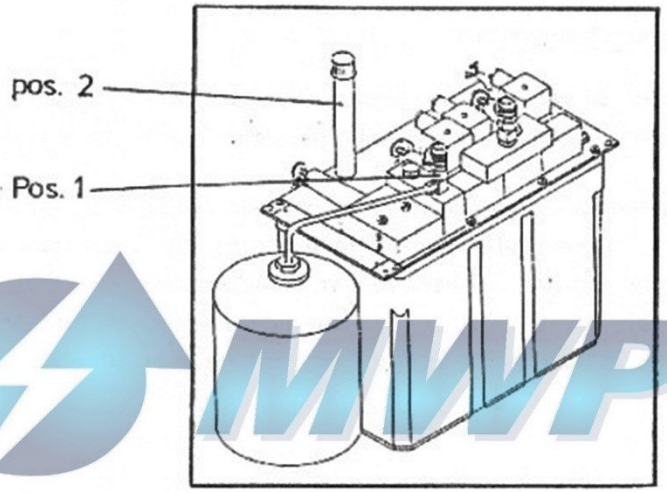
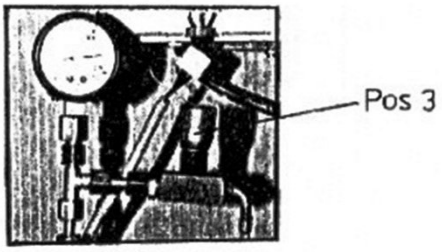
5.6.1 Pressure check brakesystem

Mount the manometer, with a bleeding hose, on the test connecting branch, from the accumulator (pos 1).
The bleeding hose ends in the refilling pipe on the brakeunit (pos 2).



If there is no pressure in the brake system, open the bleeding tap, before starting the motor. Start the motor and let it run for approx. 15 sec (pos 3). Close the bleeding tap, and the manometer will rise.

If there is pressure in the brake system, when the manometer is mounted, the bleeding tap has to be closed. When the manometer is mounted, bleed the manometer. Close the bleeding tap, and the test can start.



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5.6.2 Checking working pressure switch

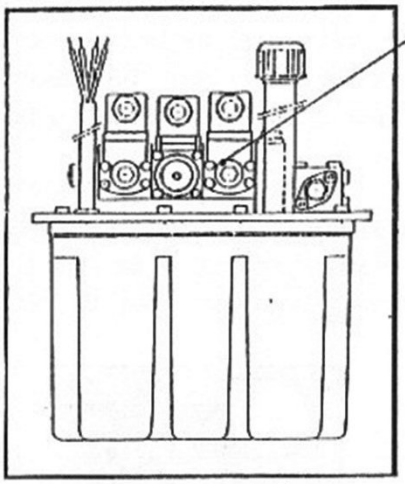
Check stop pressure

When the pressure reaches 150 bar ± 2 bar the working pressure switch will disconnect, and the brake motor stops.

Check start pressure

In order to release the pressure from the brake system, it is necessary to manually activate the magnet valve (see picture).

The brake motor has to start at 140 bar ± 5 bar. If the stoppressure is correct adjusted on 150 bar, and the brake motor do not start at 140 bar ± 5 bar, but at a lower pressure, it is caused by to big hysteresis. The working pressure switch can not be adjusted. Therefore the pressureswitch has to be changed.



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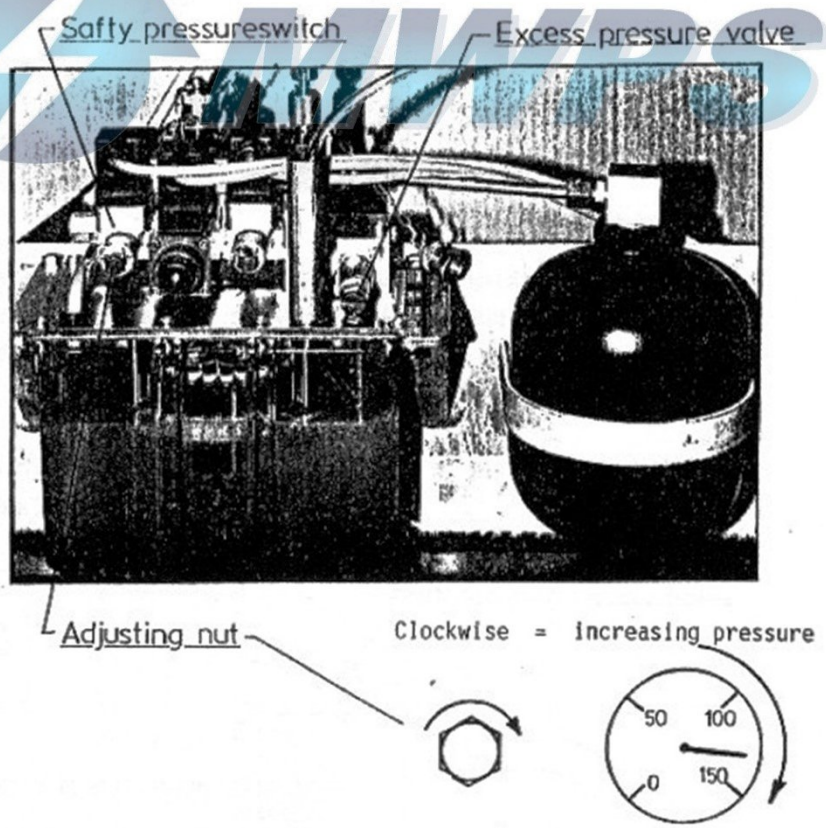
5.6.3 Check of safety pressure switch

Take of the working pressure switch plug, which will remove the motor function. In order to release the pressure from the brake system, it is necessary to activate the magnet valve manually.

When the pressure is down at 130-135 bar, it will be indicated on the safety lamp in the relay controller. For the micro processor controller, the low pressure will be indicated in the display. If the lamp is not activated when the pressure is about 130-135 bar, the safety pressure switch has to be adjusted.

The adjustment is done by means of the nut. Clock wise is up the manometer scale.



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5.6.4 Check of accumulator (preloading)

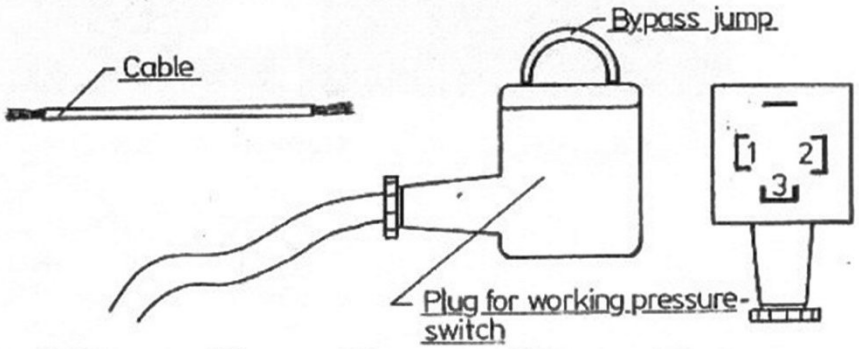
Keep the magnet valve activated, when the motor function is still off. The pressure will fall to 100 bar ± 5 bar. The manometer needle will then suddenly drops to 0. If the manometer needle drops at a lower pressure, the preloading pressure is to low in the accumulator.

If the preloading is to low, change the accumulator.

Excess pressure valve

Connect the working pressure switch again. The brake motor will start. When the pressure is at 150 bar the brake motor stops. Remove the working pressure switch plug and make a bypass jump between 1 and 2 in the plug.

The bypass jump can be made with a small piece of cable.



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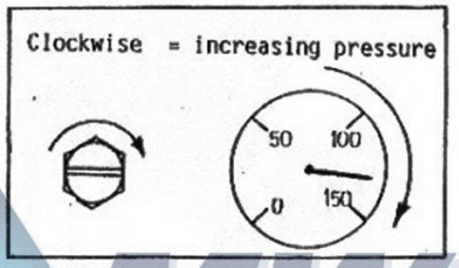
5.6.5. Check excess pressure valve

The bypass jump will force the brake motor to rise the pressure to exceed 150 bar. The excess pressure valve shall work at 160 bar. If not, adjust the excess pressure valve (pict. page 5.6.3.) on the screw fig. 1. When the adjustment is done on the excess pressure valve, remove the bypass jump.



If the excess pressure valve is loosing pressure all the time, try to tighten up the hexagon nut as much as possible. Then loosen it out to normal position again. If it does not work, change the excess pressure valve.

If the excess pressure valve is leak, the brake motor will run very offent, because it is loosing pressure all the time.

Activate the magnet valve manually, so the pressure falls down to approx. 150 bar, normal working pressure.

Dismantle the manometer.

The brake system will now run normally.

Clean the brake unit for wasted oil.

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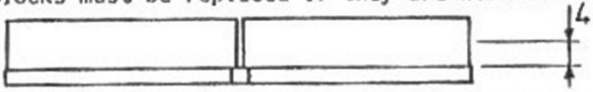
5.7.1 CHANGE OF BRAKE BLOCKS

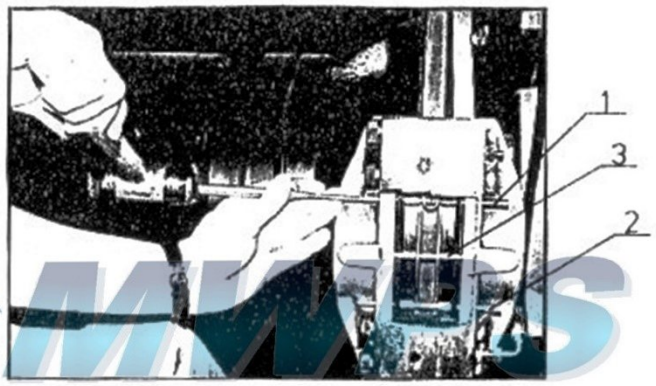
The brake blocks must be replaced if they are worn with only appr. 4 mm left.



In this connection it has to be mentioned that one braking at high wind, wears up till 1 mm of the blocks will take place. Therefore it is advisable to replace the block regularly.

Tools:

Flat-bit pliers
4 mm screwdriver
4 mm piercing plug
Handhammer
14 mm ring key
Clean can



Procedure:

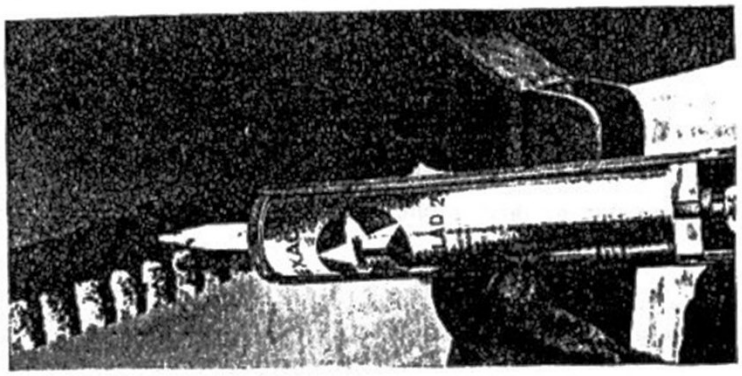
The key is turned to 0. When pressing and releasing the top of the solenoid valve repeatedly the storing pressure is decreased from the brake system.

By means of the hammer, split no 1 is removed after which splits no 2 and 3 can be removed as well as the 2 plates. By means of the screwdriver the brake block is pushed as far away from the disk as possible. At the same time the can is hold under the bleeding screw (4- which has to be dismantled) as the oil is now coming out. (see picture bleeding brake system)
The new brake blocks can now be placed. The splits can also be placed.

Note: Bleed thouroughly and test the brake afterwards.

5.8.1 LUBRICATION YAWING SYSTEM

The yawing system is exposed to wind and weather. Therefore as a consequence it is of vital importance to secure correct lubrication of these parts.



Tools:

Grease gun
2" brush
Scraper

Procedure:

The yaw tooth is cleaned for dirty grease. Refrain from letting the grease drop down to the ground. Otherwise some of it might stick on the mast and in taht way cause direct danger when crawling in the mast.

The soiled grease can instead be collected in a box etc.

By means of the grease gun the teeth is smeared with a thin coat of grease. The grease is spaced on the tooth plate with the brush.

The track which the slide blocks of the top section describe is covered with a thin coat of grease as well.

Especially here it is of vital importance with a thorough cleaning for impurities. The coat of grease must be as thin as possible.

The lubrication has to be done every time there is maintenance, service done on the turbine.

Address:
VESTAS ENERGY A/S
POSTBOX 42
DK 6940 LEM
DENMARK

Telephone:
+45 7 34 11 88

Telex:
60 733
VESTAS DK

Telefax:
+45 7 34 14 84

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5.8.2 Maintenance of yawing gear-wheel

Gear-wheel and pinion in the yawing arrangement must always be lubricated (see "Lubrication yawing system").

As there are large contens of dust in the air at intervals, this will cause that a lot of dust might accumulate on the gear-wheel and on the pinion.

It is of the most vital importance that the gear-wheel and the pinion are kept under observation currently and are cleaned thoroughly if dust is found which might cause break-downs and wear.

After cleaning the gear-wheels have to be lubricated before the turbine is set into operation again.

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DK 6940 LEM
DENMARK

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Telex
60 733
VESTAS DK

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+45 7 34 14 84

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5.8.3 Lubrication yaw system

Alternative grease qualities

Esso:	Esso MP grease, beacon (Moly)
Mobil:	Mobil grease special
Shell:	Kuggfett
Texaco:	Teclad 2
BP:	BP tandhjulsfedt

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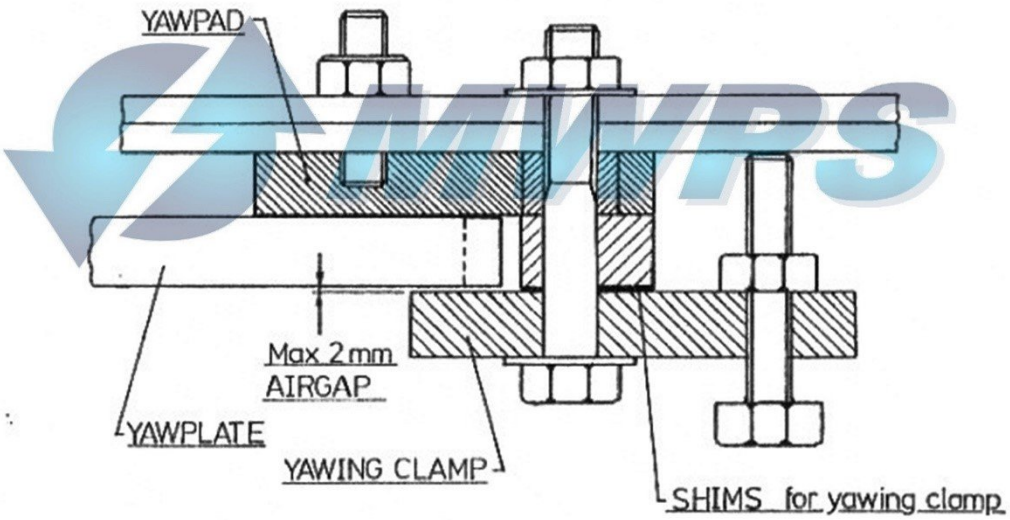
5.9.1 Check of yawpads

Check all 4 yawpads for airgab between yawplate and yawing clamp, every time there is maintenance done on the turbine.

There is no exact schedule for changing the yawpads.

Maintenance of yawpads is to adjust the yawing clamp. There must be max 2 mm airgab. If the airgab gets bigger, caused by wear on the yawpads, the adjustment can be done by removing 1 of the 2 shims for the yawing clamp. Each shim is 1,5 mm. Keep the removed shims. They will be used again when it is necessary to change the yawpads.



When both shims for the yawing clamp have been removed, the yawing clamp can not be adjusted anymore. If it can not be adjusted anymore, and the airgab gets bigger than 2 mm, contact Vestas service department.

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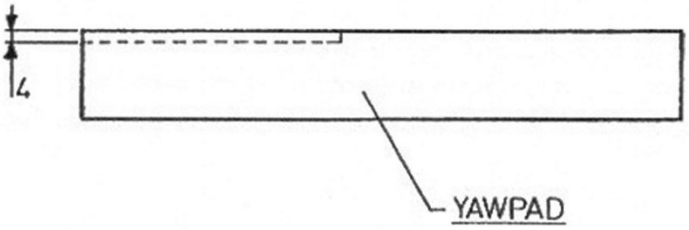
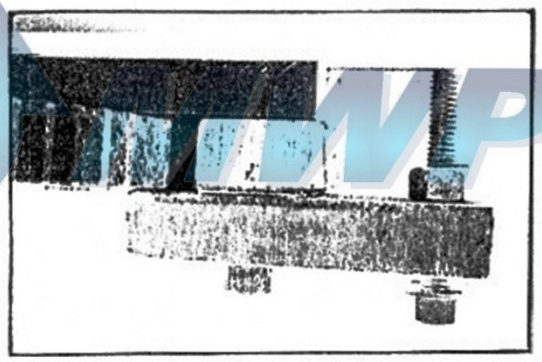
5.9.2 The yawpads is only allowed to wears 4 mm.



Note: No, lubrication on the yawpads. See "Grease yawing system".



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Telex:
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VESTAS DK

Telefax:
+45 7 34 14 84

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5.10.1 Oil change yawinggear:

The gear does not need any maintenance according to oil check/change or greasing, as the gear is greased for life, which means that the oil/grease check/change only is carried out when the gear is over-hauled.

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DK 6940 LEM
DENMARK

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+45 7 34 11 88

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VESTAS DK

Telefax:
+45 7 34 14 84

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5.11.1.

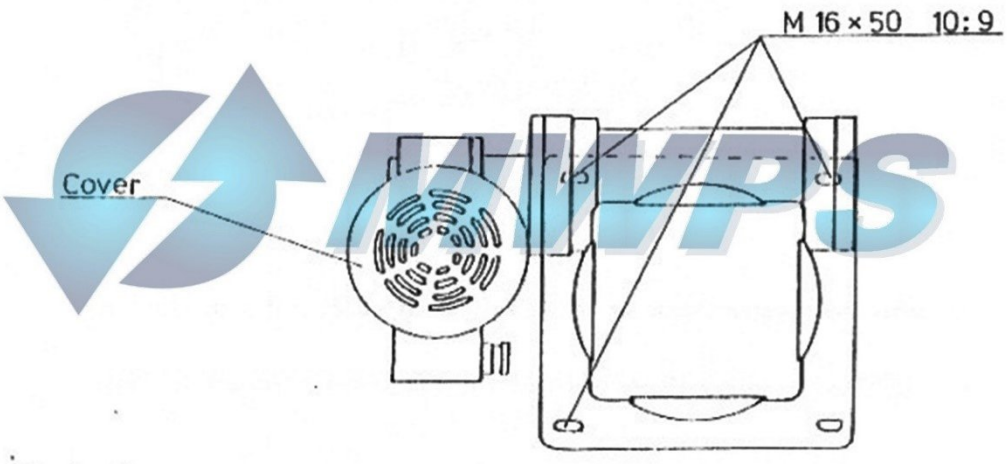
Adjustment of yawgear

In case of natural wear on the center ring, the yaw gear has to be adjusted when the airgap between the yawgear wheel and the yawplate exceeds 0,5-1 mm.

(Acc. to skitch next page)

Adjustment must also be done if the airgap of other reasons (uncorrect tightning, etc.) exceeds the described value.

Adjustment has to be done every time there is service done on the turbine.



Adjustment

A Loosen the 3 (M16) bolts in the yawgear.

B Take of the cover of the yawgearmotor.

C Turn the fan by hand, so one of the teeth in the yawgear wheel points towards the center of the yawplate.

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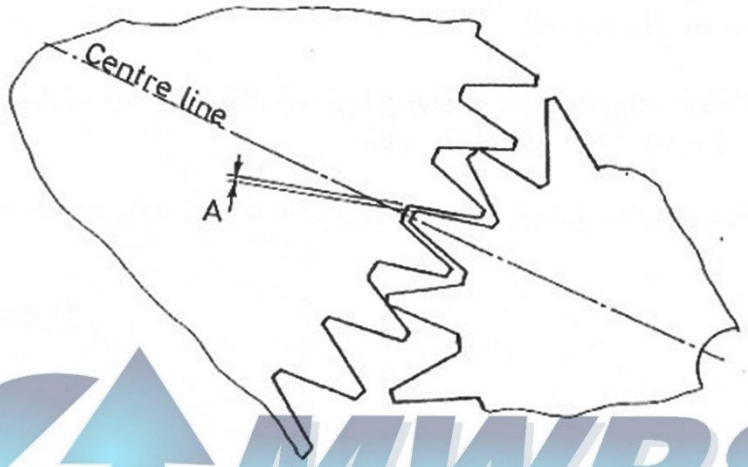
5.11.2

D Press the yawgear in direction of the yawplate so the teeth are in the bottom position, and there is no airgap.



E Move the yawgear back so "A" the airgap is 0,25 - 0,5 mm appears.

F Tighten the bolts (M 16x50 10:9) for the yawgear (torque 295 Nm)

5.12.1. Check of detwist yaw (relay controller)

To check the detwist unit, press the yaw button c.w.  or c.c.w.  . Start yawing in the same direction as the turbine cables are twisted before the test.

Checking the twisting direction can be done visual, by entering the tower.

Before checking the detwist yaw, brake the propeller manually.

Keep activating the yaw button untill the turbine stops.

In case of the relay controller, the red lamp "cable untwist" will be on. Release the yaw button and the turbine will detwist automatically, if the conditions are as described in section 5.12.3.

The same procedure is done the other way around. Explanation for the controller panel, acc. to next page.

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VESTAS ENERGY A/S
POSTBOX 42
DK 6940 LEM
DENMARK

Telephone:
+45 7 34 11 88

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60 733
VESTAS DK

Telefax:
+45 7 34 14 84

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8 84 73 98

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5.12.1. Check of detwist yaw (micro processor controller)

To check the detwist unit, press the yaw button c.w.  or c.c.w.  . Start yawing in the same direction as the turbine cables are twisted before the test.

Checking the twisting direction can be done visual, by entering the tower.

Before checking the detwist, brake the propeller manually.

Keep activating the yaw button untill the turbine stops.

In case of the micro processor controller, the display will write "twist stop release". Release the yaw-button and the turbine will detwist automaticly, if the conditions are as described in section 5.12.3.

The same procedure is done the other way around. Explanation for the controller panel, acc. to next page.

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POSTBOX 42
DK 6940 LEM
DENMARK

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Telex:
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VESTAS DK

Telefax:
+45 7 34 14 84

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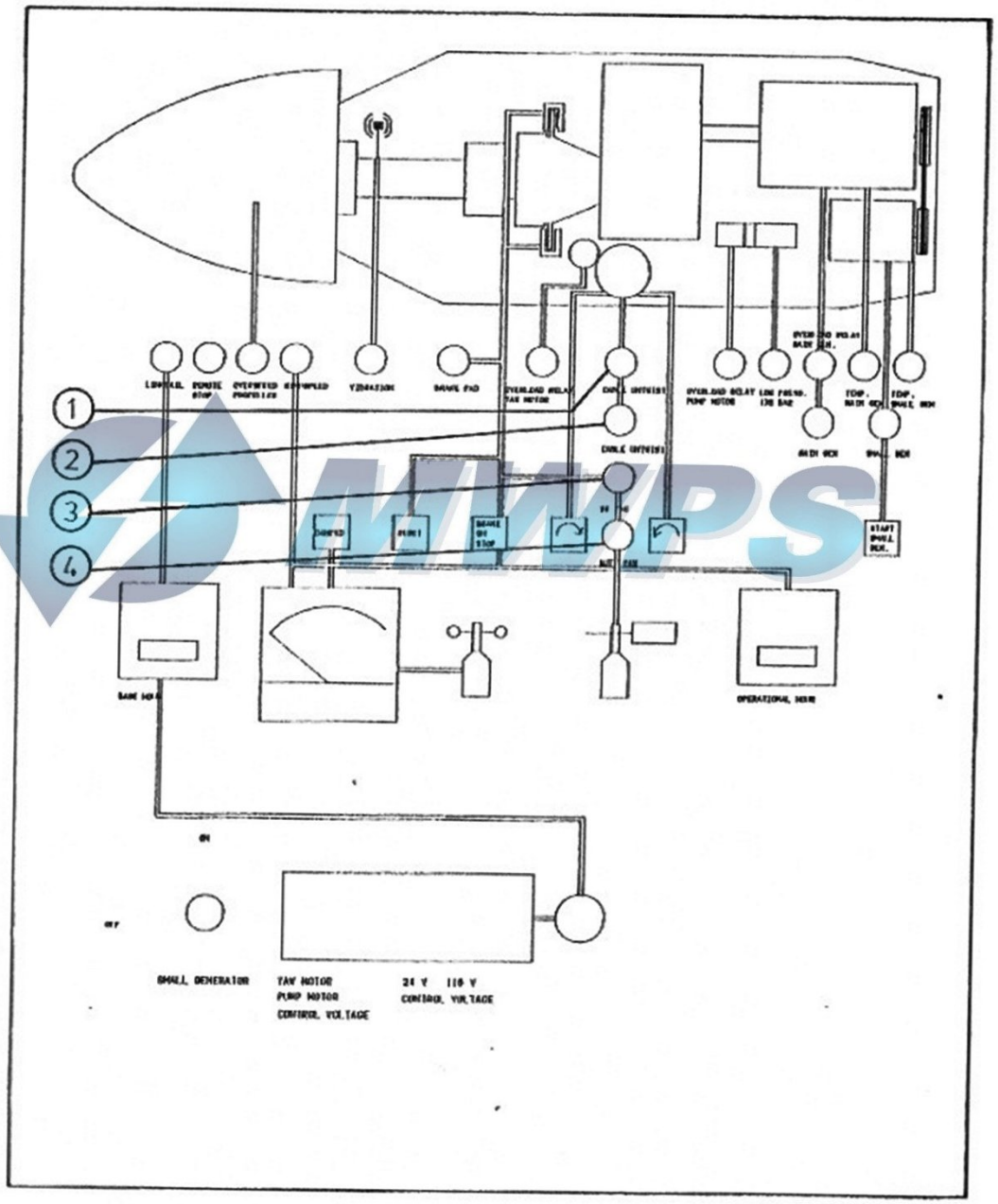
5.12.2

PANEL FOR RELAY BASED CONTROL UNIT



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DENMARK

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60 733
VESTAS DK

Telefax:
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5.12.3. Explanation for yaw lamps on the control panel

1. Cable untwist (red lamp)

The light indicates the windturbine is braked, caused by twisted cables.
The cables will automatically untwist, if the turbine is not braked, under following circumstances:

1. The turbine has been braked by propeller overspeed guard.

2. The turbine has been braked by a overload yawmotor relay.

The windspeed has to be below 13 m/s (30 mph).
The turbine is automatically reset (see pt. 19) when untwisting is finished. The turbine can be manually untwisted by using either the c.c.w. or c.c. buttom, and then press the reset buttom (see pt. 21 and 22).

2. Cable untwist (yellow lamp)

Indicates, the windturbine has started automatic cable-untwist operation. The turbine will not start automatically untwist under following circumstances:

1. The turbine operating on the main gen.

2. The turbine braked by means of the overspeed guard or has braked by means of overload yawmotor relay.

3. The windspeed is above 13 m/s (30 mph).

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5.12.4.

3. 90 deg. yaw (yellow lamp)

Indicates the nacelle/propeller is yawing to a pos. of 90 deg. out of the wind direction. The 90 deg. yawing is always c.c.w. and it is completed within 90 sec. The windvane will ensure the propeller position.

The 90 deg. yawing can be stopped by a cable untwist operation (see pt. 7 and 13). The 90 deg. yaw will continue after cable untwisting.

When the nacelle yaws 90 deg. the propeller has to be bracked.

4. Aut. yaw (yellow lamp)

Indicates, the turbine is reset and that the mean wind-speed is above 8 mph.
The propeller will automatically yaw into the wind direction. If the mean wind-speed drops below 8 mph, the automatic yawing is stopped and the lamp is switshed off. The automatic yawing can be disconnected by pressing the button c.w. or c.c.w. (see pt. 21 and 22).

By referring to the forementioned points, it can be seen in chapter 19 "OPERATING MANUAL FOR CONTROLLER".

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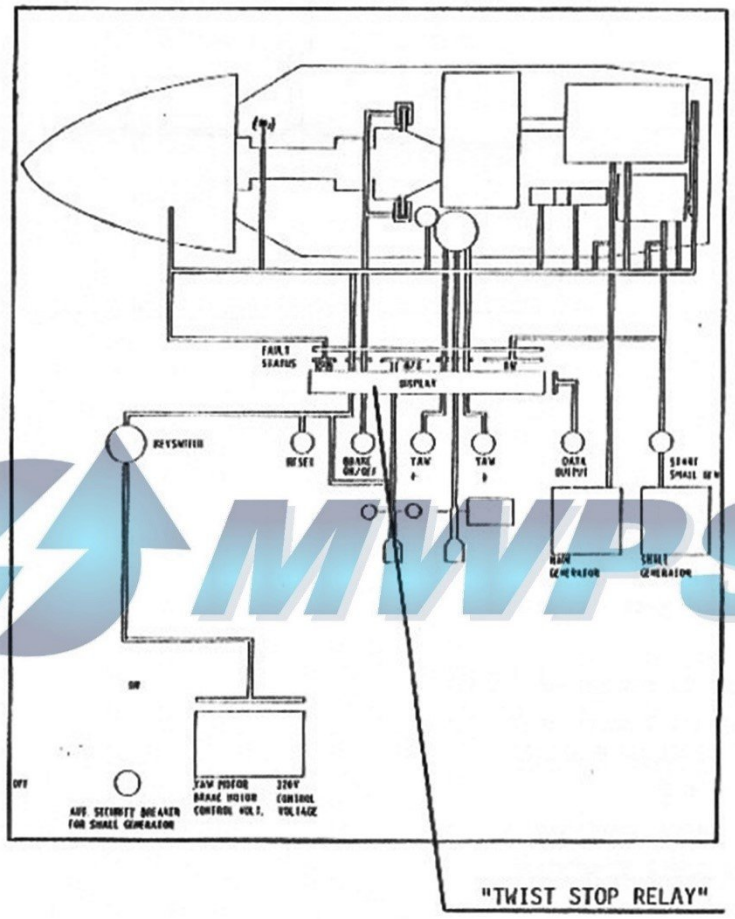
5.12.5

PANEL FOR MICRO PROCESSOR BASED CONTROL UNIT



The condition for untwisting has to be the same as for a relay based control unit.

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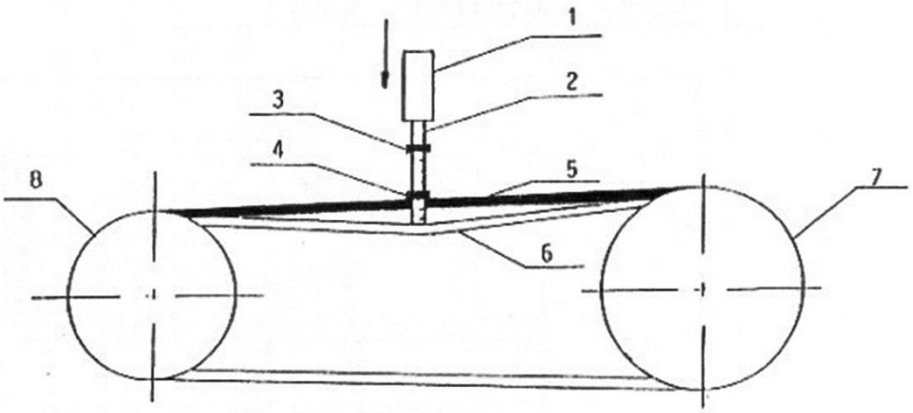
5.13.1 Adjustment of V-belts:



1. Handle of test equipment
2. Scale
3. O-ring, is placed on 7,5 KP
4. O-ring, is placed on 10 mm
5. Front belts no A and B
6. Rear belt C
7. Pulley main generator
8. Pulley small generator

It is of extreme importance that the belts have the right tightness, if not it might cause damage to the generator bearings and/or the life-spand of the belts might be shorter.

Adjustment see next page

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5.13.2 Adjustment:

By using the gauge (1) on the rear belt (6) and let the two other belts (5) be in their straight position, it is possible to measure the tightness of the belt.

1. O-ring no 4 is placed ____ mm from the lower end of the scale (2).
2. The O-ring (3) is placed on _____ kpm (look at the scale).
3. When O-ring 4 reachs the top side of V-belts A and B and the lower part of the handle (1) reachs O-ring no 3 all at the same time - the tightness is according to the test bed.

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DENMARK

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VESTAS DK

Telefax:
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5.14.1. Change of V-belts:

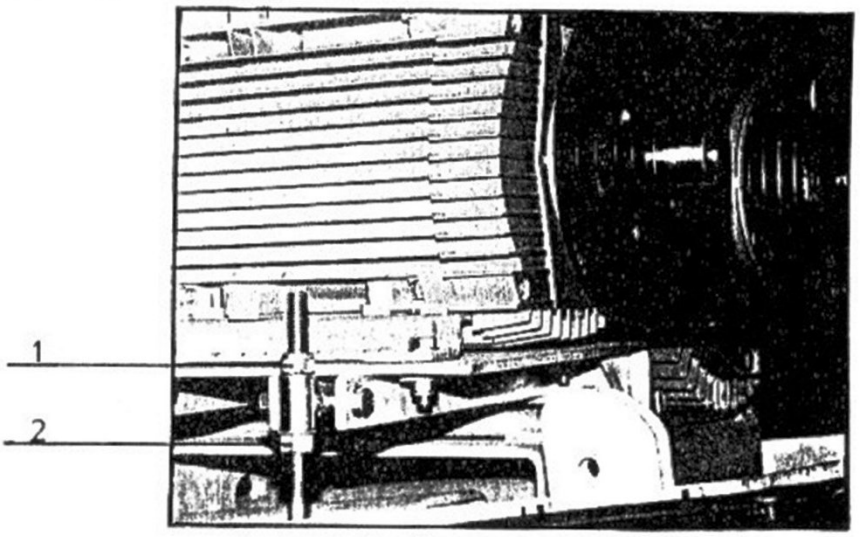
The belts have to be changed every third year.
It might however be necessary to change them more often. Therefore they should be checked every time one is in the nacelle. On the outside the belts might look fine, whereas there can be crack formations on the inside. - Look for that!

How often it is necessary to change the V-belts, depends on a lot of factors, weather conditions, how many up and down couplings between the generators, the V-belt torque, e.c.t.

So it can be necessary to change the V-belts in other intervals than the 3 years.

Belt change:

1. Release nut no. 1.
2. Unscrew nut no. 2 - by this it will be possible to take of the belts.
3. In the reverse order the belts are fitted again (according to tightners see "Adjustment of V-belts").



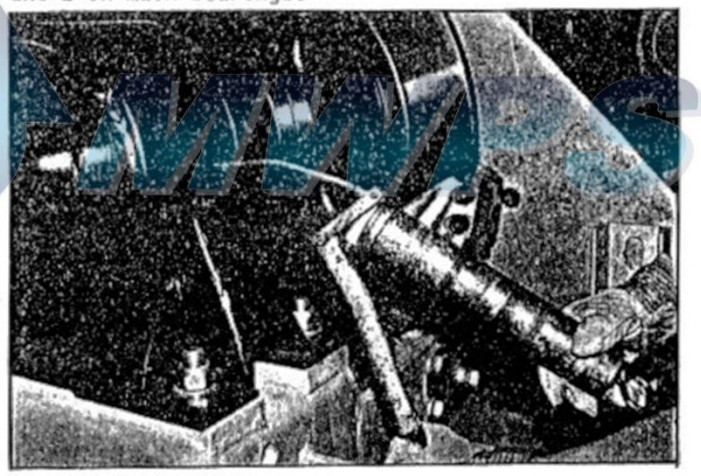
5.15.1 LUBRICATION OF BEARINGS:

To lubricate the bearings and the propeller main shaft is of extreme importance. It have to be lubricated every 12 month, following the lubrications diagram.

If not, it might cause damage to the bearings and shaft, and the lifespand will be shorter.

Lubrication with:

Grease: gun
Grease: SKF LGEP 2
Quantity: 0,4 kg even distributed at 3 nipples, 1 on main shaft and 2 on main bearings.



Cleaning

Before and after lubrication, clean the grease nippels for old grease and dust.

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DENMARK

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5.16.1 Lubrication of generator

The bearings in a ASEA generator have to be lubricated every 12 months.

Lubrication is done with a low pressure grease gun, through a nipple on each bearing. Before lubricating a bearing, clean the nipple to prevent the dirt from accompanying the grease into the bearing.

Big generator 80 G pr. bearing.
Small generator 40 G pr. bearing.

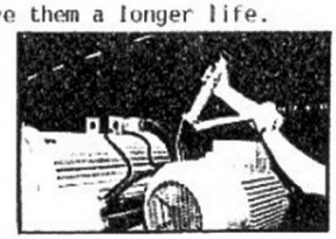
1 pump with a normal low pressure grease gun is approx. 2 G.

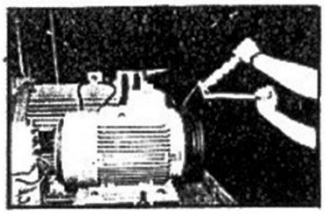
Lubrication has to be carried out while the turbine is stopped. Because the turbine is not running, it is only recommended to grease the bearings with the half of the grease quantity. When all the bearings have been greased with the half of the recommended quantity, the turbine has to be started, and run for a few minutes at full speed.

Stop the turbine again, and finish the lubrication. Lubricate with at least the specified quantity of grease until the grease exudes from the grease outlet.

If the entire quantity of grease is forced in at the same time while the machine is standing still, there is a risk that part of the grease will penetrate into the generator through the inner bearing seal.

An extra lubrication of new bearings after a few days running, will give them a longer life.





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5.16.2 Lubrication of generator

Alternative grease qualities

SKF:	ALFALUB LGMT 2, LGEP 2
ESSO:	BEACON 2
MOBIL:	MOBILUX 2
SHELL:	ALVANIA GREASE R2
TEXACO:	TEXANDO FO 20, MULTIFAK EP 2
BP:	ENERGREASE LS 2

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5.17.1 Change of bearings in generator

Changing of the bearings has to be done when the bearings starts to make noise. Sometimes the noise is very loud, easy to hear. Sometimes it's necessary to put a screwdriver on the end cap of the generator when it's running. Put an ear to the screwdriver, and it's possible to hear if there is anything wrong with the bearing. If the noise starts in the first year the turbine is running, there has been a failure in the bearing. If the noise starts later on, it's caused by needed or wrong lubrication.

When bearings start to make noise, lubricate them, and if the noise appears soon again, change them. It don't have to be both bearings there have to be changed.

Bearings size:

SKF roller bearings:	Front bearing	Rear bearing
Big generator ASEA	6316/C3	6318/C3
Small generator ASEA	6310/C3	N 312

If it is the rear bearing which has to be changed, the V-belts have to be dismantled first. See page 5.14.1. "Changing of bearings". Taper lock and pulley have to be dismantled next (see next page).

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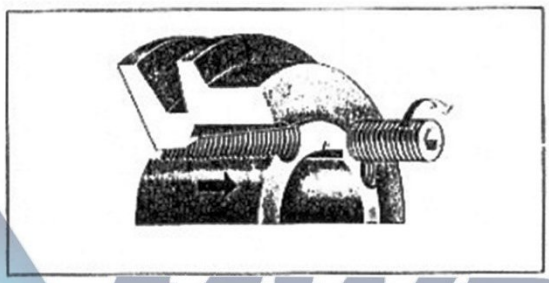
Dismantling of taperlock and pulley

Pull out all the screws. One of them is placed in the thread hole belonging only to the bush.

The pulley is now loose and can be removed.



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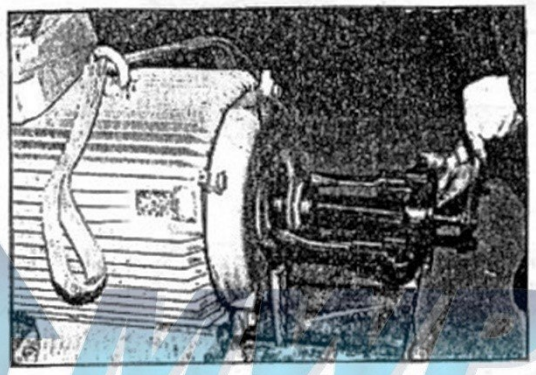
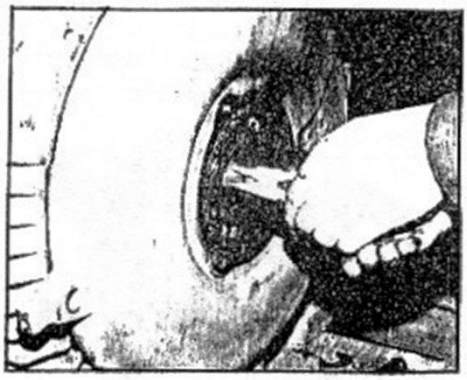
5.17.2 Changing bearings in generator

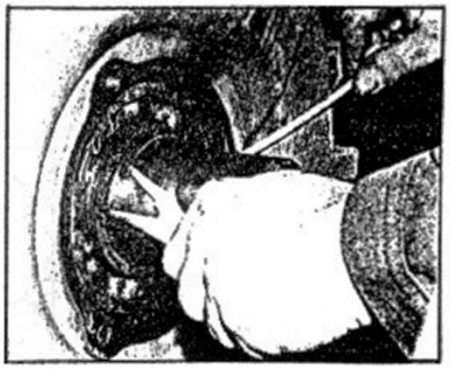
Procedure:

Dismantle respectively the cardan joint in front or the V-belt sheave rear. Depends on if it is one or both bearings there have to be changed.



Dismantle the end cap. If it can't be removed by hand, use a wheel pullen.





Dismantle the losking ring, that holds the bearing in place.

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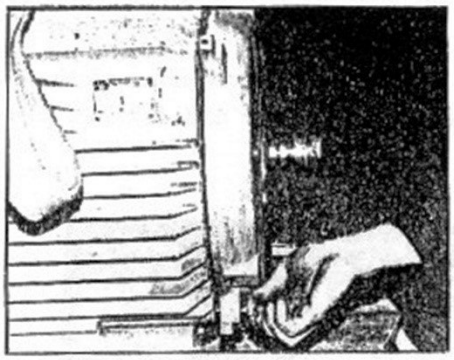
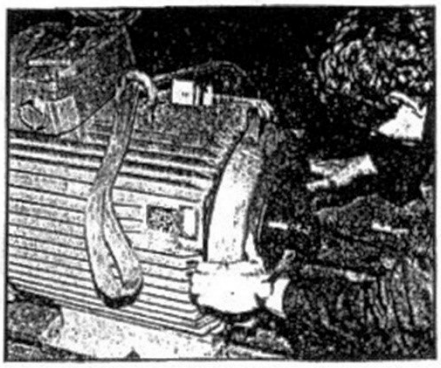
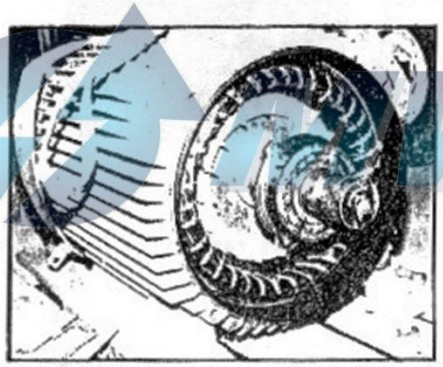
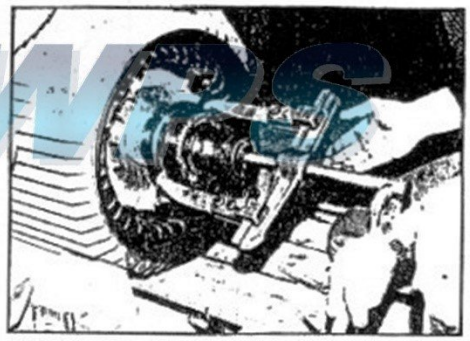
5.17.3 Change bearing generator



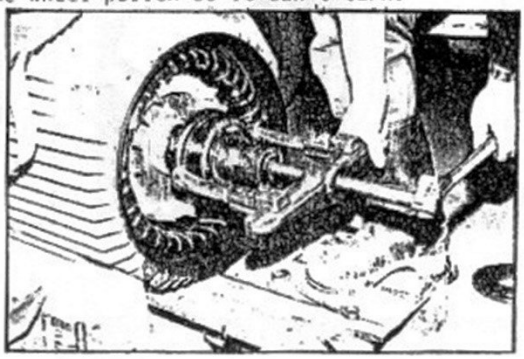


Dismantle the large end cap.





Now dismantle the defect bearing, by using a trigger. If the bearing is sitting to tight to hold the whell pullen with the hand, put something under the wheel pullen so it can't turn.



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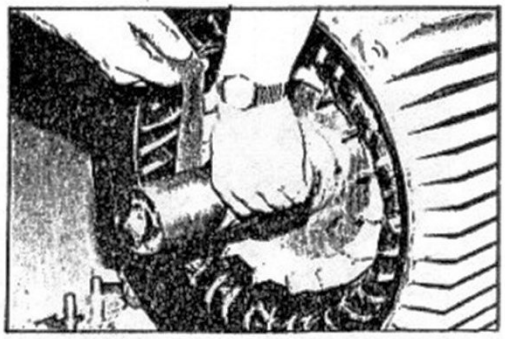
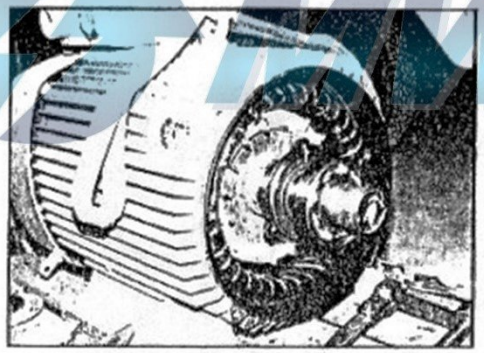
5.17.4 Change bearing generator



Clean the shaft and end caps for old grease and dust.



Mount the new bearing. If it's to difficult to press the bearing on the shaft, heat up the new bearing, and the bearing will slide on.

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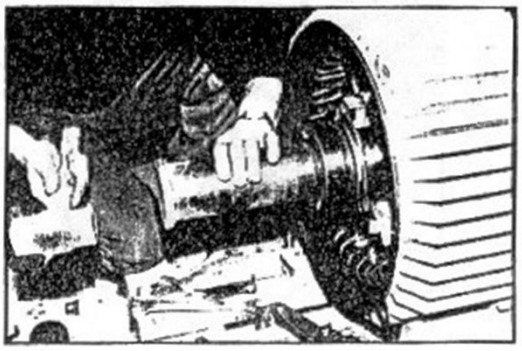
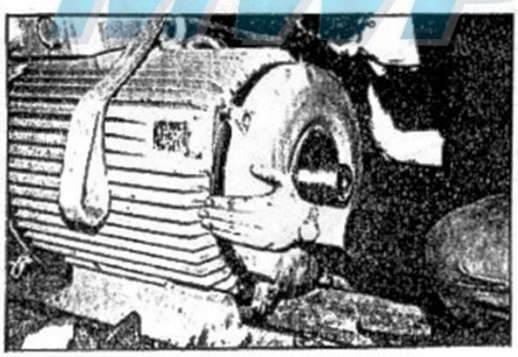
5.17.5 Change bearing generator



Use a pipe and a hammer to make sure the bearing is placed correct.
By hammering the pipe in, the bearing will be easy to hear.



Mount the large end cap.
Mount the locking ring and the small end cap.

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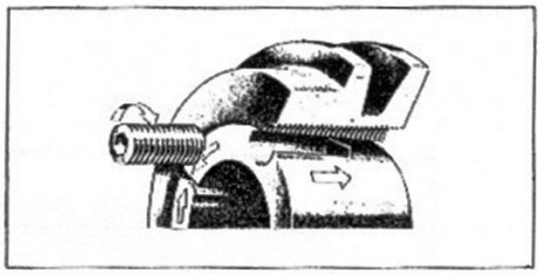
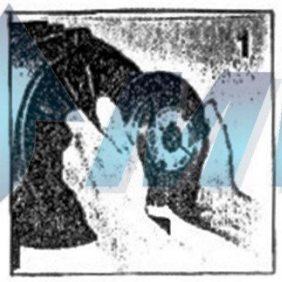
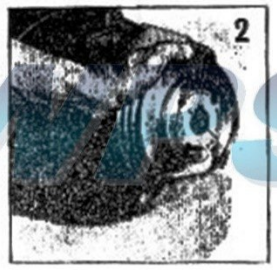
5.17.6. After mounting the end cap, the pulley and taper lock have to be assembled again.







Insert the bush in the pulley and line up the holes. Put the screws in the holes where the tread is in the pulley.

Place the unit on the shaft.

Line up the pulley and tighten the screws. By this the bush is pulled into the pulley, and at the same time it will press around the shaft.

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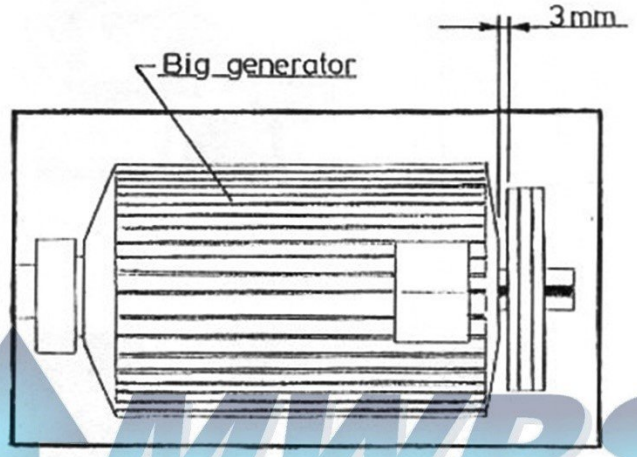
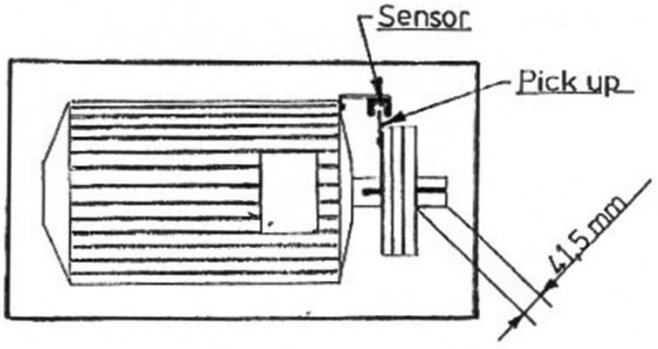
5.17.7. If it is the rear bearing on the big generator which has been changed, the pulley has to be mounted 3 mm from the shaft end again (fig 1).



If it is the rear bearing on the small generator which has been changed, the pulley has to be mounted 41,5 mm from the shaft end (fig 2). The small pulley has to be placed so the pick up is running exact in the sensor.



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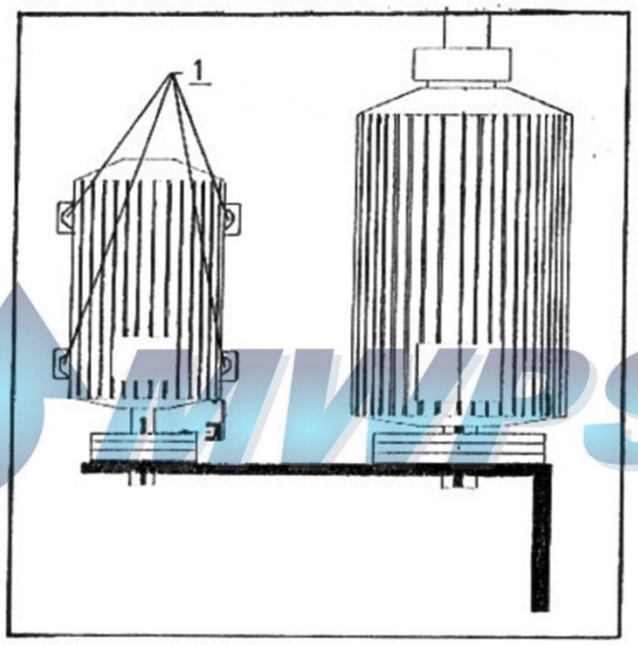
5.17.8. To avoid a unnecessary wear on the V-belts, the two pulleys have to run exactly in line.

When the pulley is placed as described, check with a steel ruler or a steel angle, if the pulleys are in line (see fig 1.)

If a line up is necessary, loosen bolts no. 1



If the pulleys are not in line, loosen the small generator and line up the pulleys, by moving the hole generator.
The line up is always done from the large pulley.

Remember:

Tighten the generator again with the described torque (acc. to page 5.19.2.)
Adjust the V-belt (acc. to page 5.13.1.).
Lubrication of bearings (acc. to page 5.16.1.)

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5.18.1 Maintenance of Airbrakes (wingtips):

Usally the airbrakes (tip-end of blades) need no maintenance. But wear might change clearance and through that preload of the spring system possible causing an activation of the tipbrakes at to low rotor revolutions.
If this occurs further detailed informations about adjustment must be given by VESTAS.

Test of airbrakes

Test of the airbrakes have to be done by Vestas service department or with specially permission from Vestas.

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5.19.1. Check bolts

Foundation bolts

All foundation bolts have to be retightened every 12 month. Tightening have to be done with a inpact wrench and a 1 kg hammer.

Bolts dimension:	Lattice tower	Tubular tower
	M 38	M 39

Tower

All bolts in lattice and tubular tower have to be retightened every 12 month.

Bolts dimension:	M 20	M 16
Torque:	490 Nm	250 Nm
Torque (US):	361 lbf ft	184,3 lbf ft

Platform

All bolts on both platforms have to be retightened every 12 month.

Bolts dimension:

Torque for bright galvanized bolt:	Torque	Torque (US)
M 6	9.8 Nm	7.2 lbf ft
M 8	24.0 Nm	17.7 lbf ft
M 10	47.0 Nm	34.6 lbf ft
M 12	81.0 Nm	59.7 lbf ft

Blades and hub

All bolts and counter nuts on blades and hub have to be retightened every 12 month. For the retightening it is necessary to dismantle the spinner. Tighten the bolts first, and then the counter nuts from the inside.
Torque for M 24 = 757.5 Nm
Torque (US) for M 24 = 558.0 lbf ft

Moving parts

Every time there is lubrication, maintenance or anything else done on the turbine, check the bolts on moving parts (see next page).

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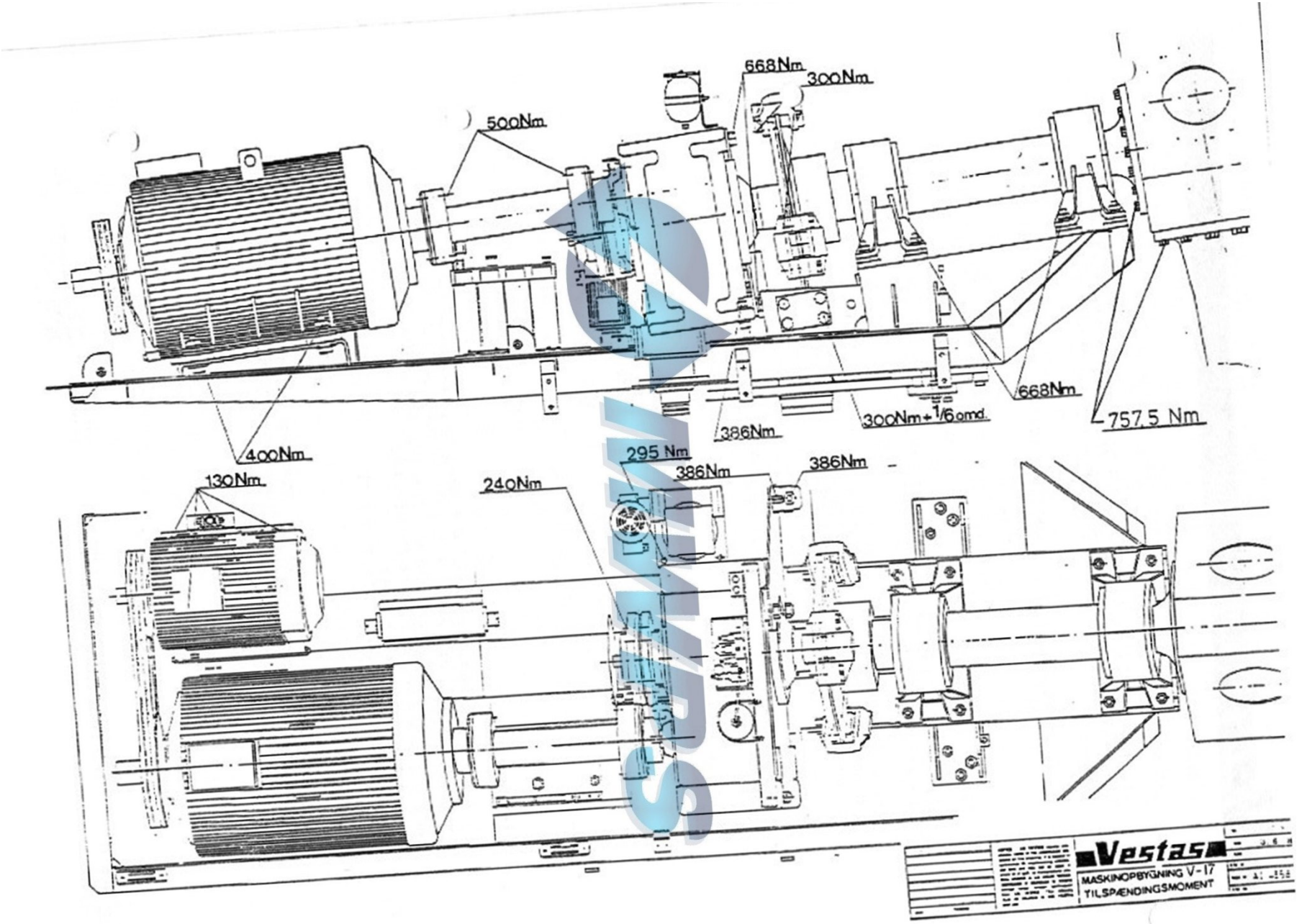
668Nm
300Nm
500Nm
668Nm
757,5 Nm
300Nm+1/6omd.
386Nm
400Nm
295 Nm
386Nm
386Nm
130Nm
240Nm
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TILSPÆNDINGSMOMENT

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5.19.2A. Conversion table torque

Torque Nm	Torque (US) Lbf.ft.
130	96
240	177
295	217,5
300	221
386	284,5
400	295
500	368,5
668	492,5

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DENMARK

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VESTAS DK

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DEN DANSKE BANK

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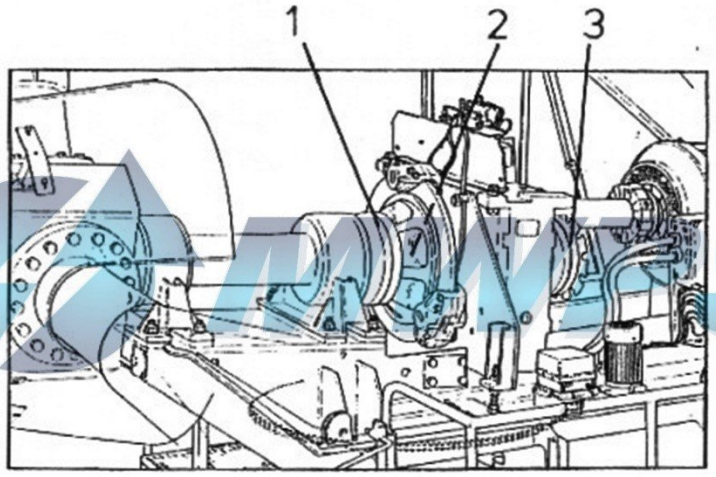
5.19.3. Check bolts on shrinkelements

All bolts on shrinkelements have to be retightened every 12 month.

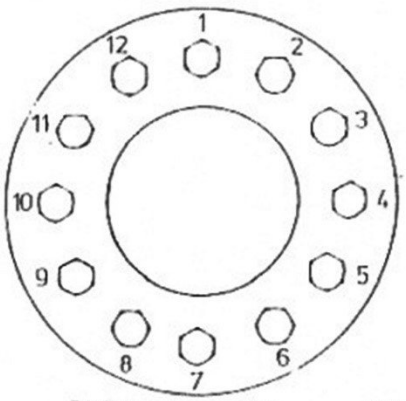
The shrinkelement on the propeller mainshaft.

	Type	Torque	Torque (US)
1	Ringfeder	250 Nm	184 lbf ft
	Heuer	240 Nm	177 lbf ft
2	Ringfeder (inside the brake disk)	130 Nm	96 lbf ft
3	Heuer	240 Nm	177 lbf ft

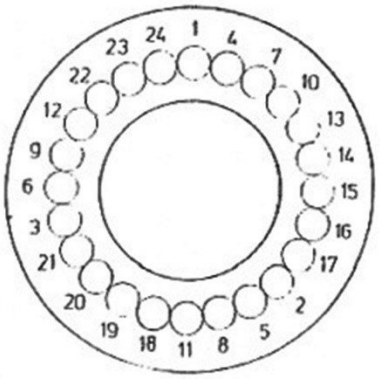


The shrinkelement have to be retightened in following numerical order.

1 and 3



2



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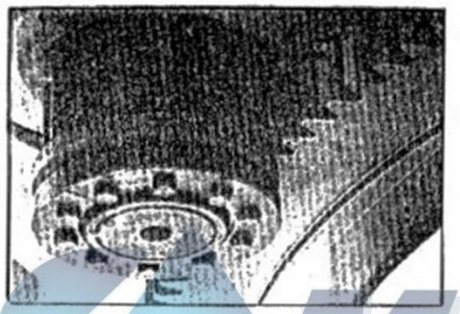
5.19.4. Check bolts on shrinkelements

The shrinkelements on the end of the yawgear shaft have to be retightened with:

Torque : min 12 Nm, max. 15 Nm

Torque (US): min. 8.8 lbf ft max. 11 lbf ft



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Specifications for torque

If there is no special torque for the specific bolt, it have to be tighten after the following diagrams respectively for 8.8 bolts bright galvanized and 8.8 bolt heat galvanized.

Bolt quality: 8.8.

Surface nature: screw, nut, washer } heat - galvanize

Assembling condition: Dry (no oil or grease)

Bolt dimension M (MM)	Torque Nm	Torque (US) Lbf.ft.
6	12	8,8
8	30,5	22,5
10	59,5	44
12	102	75,5
14	163	120
16	250	184,5
18	350	258
20	490	361
22	659	486
24	847	624,5
27	1220	899
30	1672	1232,5
33	2248	1657
36	2904	2140,5
39	3729	2748,5

The torque have to be close to the given moment value. It must not vary more than ± 5%.

The given values are only in force according to the above mentioned conditions.

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Torque

Bolts quality: 8.8.

Surface nature: screw, nut, washer } bright galvanized

Assembling condition: Dry (no oil or grease)

Bolts Dimension M (MM)	Torque Nm	Torque (US) Lbf.ft.
6	9,8	7,2
8	24	17,7
10	47	34,6
12	81	60
14	129	95
16	197	145,5
18	275,5	203
20	386	284,5
22	519,5	383
24	667,5	492
27	961	708,5
30	1317	971
33	1771	1305,5
36	2287	1685,5
39	2937	2165

The torque have to be close to the given moment. It must not vary more than $\pm$ 5%.

The given values are only in force according to the above mentioned conditions.

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5.20.1 Lamp test (relay control)

Turn the keyswitch in the control panel to pos 0. Let the keyswitch stay in pos 0 for 5 sec, and then turn it back to pos 1.

That causes light in all the red lamps, without the remote stop lamp.

If there is no light in some of the red lamps, it could be caused by a defect light bulb.

Change the defect light bulbs.

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5.21.1 Change of cardanjoint

Reasons for changing the cardanjoint

A If there is damage on the cardanjoint.

B If there is crackets in the rubber elements.

C If the rubber element have been in contact with adhesives like locitte, diuent, or something else there can have damaged the rubber.

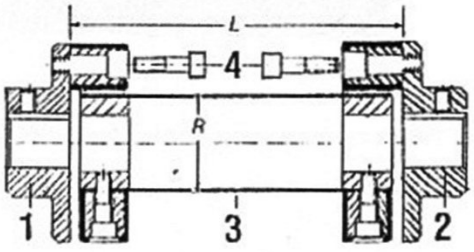
Replace of the cardanjoint

Unscrew the 8 axial bolts with a 17 mm allen wrench, and then dismantle the old cardanjoint. Check the distance between the two flanges on the generator and the gearbox. It must be 626 $\pm$ 1 mm. The new cardanjoint can be mounted between the two flanges, with 8 axial bolts (allen bolts M20). It does not matter which end of the cardanjoint there is mounted where.

Important: Always use new bolts, because the new bolts have a loctite on the screw thread.

Remember to put a bit of grease around the under side of the head of the bolts before mounting. Do not twist the rubber element, while the tightening of the bolts.

1 and 2: Flanges
3: Spacer
4: Axial bolts (allen bolts M20)



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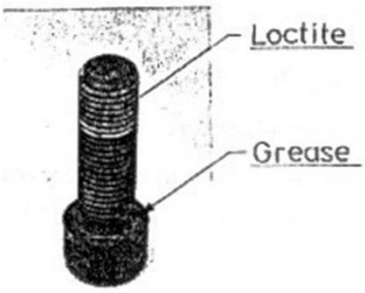
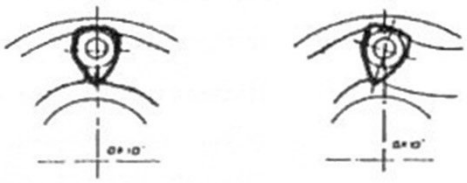
5.21.2 Greasing the bolts are of vital importance.

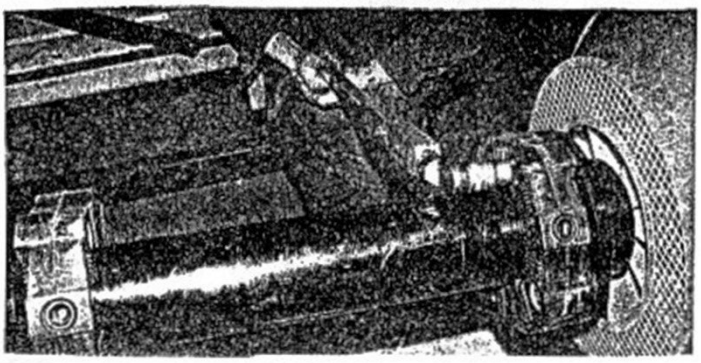




Right Wrong

Note: If there happens any twisting in the rubber element when the bolts are tightened, it must be dismantled and mounted again immediately. If it takes more than 10 min. before tightening of the bolt again, take a new bolt. If tightening before the 10 min., the same bolt can be used.

All of the axial bolts torque moment is 500 Nm



When the new cardanjoint have been mounted, check that the spacer does not move more than $\pm$ 1 mm vertically, while the turbine is running.

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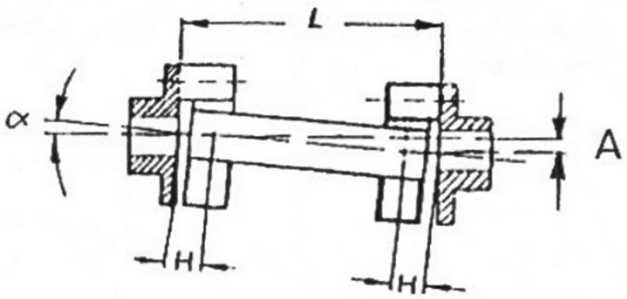
5.21.3 Check also A, the parallel displacement. It is best if A = 0.
A must not exceed 19 mm.



A = 19 mm

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5.21.4 Maintenance of cardanjoint

When the joint is new or in good working condition, there is no crackels or play to be observed. The joint needs no special maintenance. Check for crackels play or damage on the cardanjoint, every time there is lubrication or maintenance on the turbine. At least 1 time a year.

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.22.1 Check of safetyline etc.:

1. Check bracket, bolts, nuts and shackles for safety line.
2. The line is examined for rust/pitting - if some of the thin wire threads have been cut - CHANGE THE WIRE.
3. The tightness of the line should be in such a manner, that if the line is pulled away from the mast (by hand) and released, it must not touch the mast when swinging back to normal position.
   The same should be the case when the wind causes the safetyline to move.

SECURITY BELT and SLIDING BOX are allways kept in good condition.

YOUR LIFE MIGHT DEPEND ON THE SAFETY EQUIPMENT!!

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5.23.1 Maintenance of surface treatment

In order to counteract corrosion the surface treatment must be kept under observation currently.
This means that damages on painted surfaces (because of attriction or rust corrosion) must be repaired immediately.

It is recommended that damages are repaired by using a primer first and then a deck paint, but moreover in accordance with the instructions from the manufacturer of the paint.

Electro galvanized fittings, bolts, and nuts etc. are cleaned at reasonable intervals and are lubricated in tectyl or a similar surface protection.

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5.24.1 Surface renewing on blades:

Surface damage e.g. smaller cracks in coating and cracks in joint areas to steel parts must be sealed against waterponetration immediately by means of the polyurethane based sealing agent SICAFLEX. This can be done without special knowledge of the rotor material, fibre glass reinforced polyester.

The sealing procedure is as follows:

1. Remove loose material.
2. Clean the surface with acetone or similar solvent.
3. Apply SICAFLEX to the surface, in a layer as thin as possible, following the directions for use which are on the packing label.

More serious damage caused by blows during work and mounting can often be sealed by SICAFLEX as a first protection to the damage area. If this repair is judged to be insufficient a repair by polyester/fibre glass must be used. This can only be done by a person who has the appropriate knowledge of these materials.

Dust and insect covers on blade surface

Under special circumstances the blade surface might be covered by a layer of insects which might cause an unacceptable change in blade choracteristics influencing rotor efficiency.
Usally such covers will be washed away in rainy weather. If this does not happen a cleaning by washing in water might be necessary.

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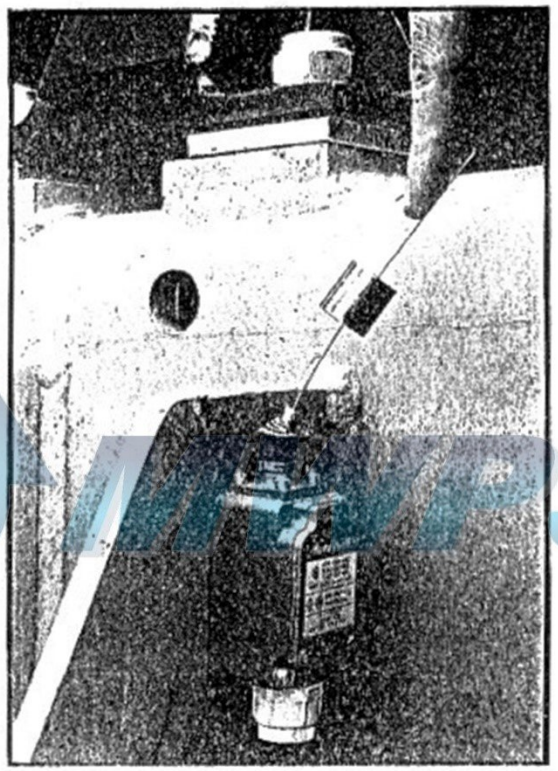
5.25 Check of chock cencor

To check the chock cencor it has to be activated manually.



The activating of the chock cencor will be indicated in the control unit, in the lamp "VIBRATION". In a micro processor controller the activating is indicated in the display. See next page.

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5.26.1. Visual check of cables

A visual check of cables has to be done every time lubrication or maintenance is done on the turbine.

Check all the cables for breakage and wear. If the cables/cables are serious damaged, the cable/cables has to be changed immediately.

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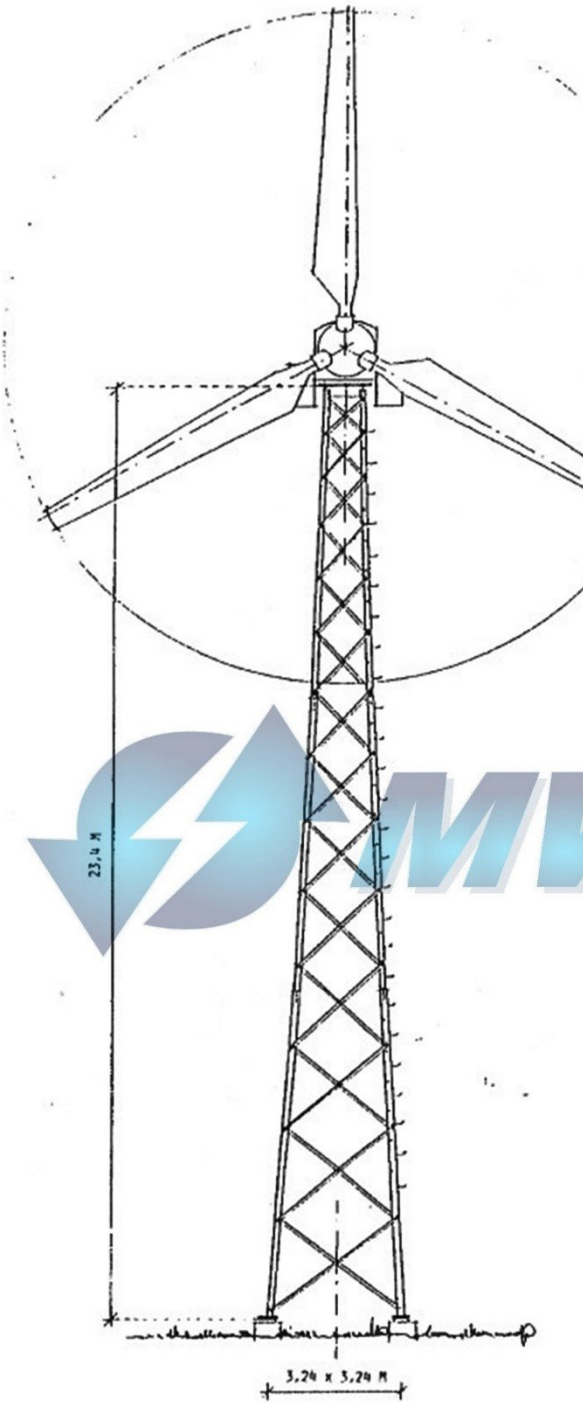


WINDMILLMAST, 23,4 M

THE MAST IS MADE WITH SQUARE CROSS SECTIONS WITH FLANGES AND LACINGS OF ANGLE STEEL.

THE MAST IS TO BE ASSEMBLED WITH IN ALL 254 M 20 BOLTS.

AT THE TOP, THE MAST IS SUPPLIED WITH MAST TOP WITH HOLES FOR ASSEMBLING OF WINDMILL WITH 20 M 20 BOLTS.

BELOW THE MAST IS SUPPLIED WITH BASE PLATES FOR FARSTENING TO THE FOUNDATION WITH 4 x 4 1½" (38 mm) FOUNDATION BOLTS. EMBEDMENT OF FOUNDATION BOLTS IS MADE BY MEANS OF DELIVERED BOLT SHAPE.

THE MAST IS AT ONE FLANGE PROVIDED WITH 51 LADDER STEPS OF WHICH 8 ARE EXTENDED FOR KEEPING A CABLE SUPPORT.

THE ANGLE STEEL IS ST. 37.2, AND THE JOINT BOLTS ARE STRENGTH CLASS 8.8.

ALL STEEL IS HOT GALVANIZED.

WINDMILL, VESTAS 75 kW / 90 kW
DIAMETER MAX. 17,5 M.

STRUCTURE DRAWINGS:

90.01 ELEVATIONS
90.02 STRUCTURAL DETAILS
90.03 ASSEMBLY DRAWING

CALCULATIONS:

DANSK INGENIØRFORENINGS CODES
DS 410.2 - WINDLOAD
DS 412 - STEEL STRUCTURES

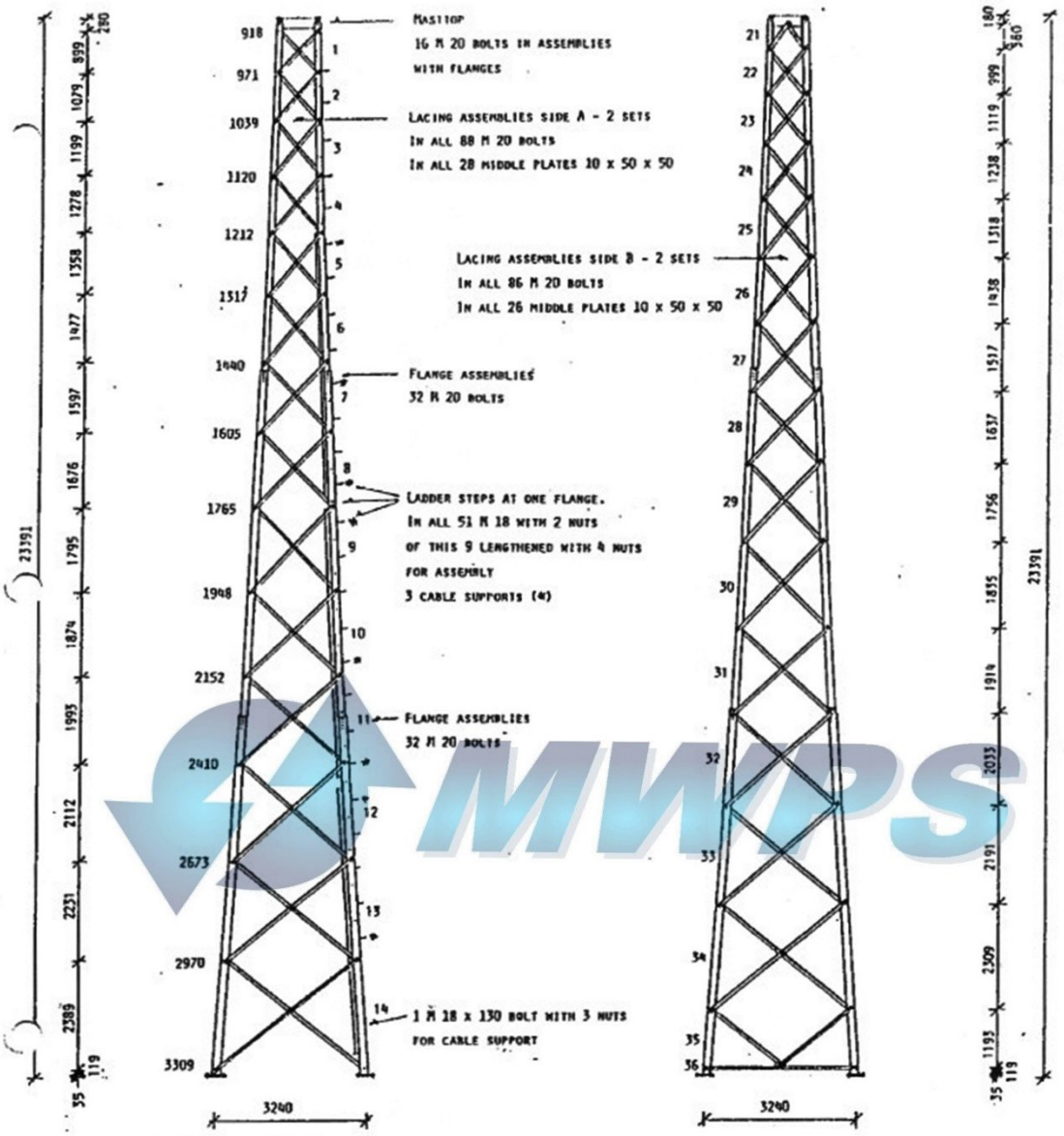
LOADS FROM THE WINDMILL
WORKING WINDMILL
I.1 - MAX. LOAD, 0,3 kN/M2 COVERED AREA
I.2 - MAX. UNSYMMETRICAL WING LOAD 0,15 kN/M2
STATIONARY WINDMILL - WIND VELOCITY v = 50 M/SEC
II.1 - MAX. LOAD FOR MILL WITH FACE TO THE WIND.
II.2 - MAX. TORSION FOR MILL TURNED 90 DEG..
C x A ⊥ <= 30 M2
C x A ∥ <= 20 M2 , e <= 1,75 M.

THEORETIC WEIGHT OF MAST 4,25 T.
INCL. MAST TOP, HOT GALVANIZING, BOLTS, LADDER STEPS, CABLE SUPPORTS ETC., BUT EXCL. FOUNDATION BOLTS.

(VARIATIONS -0 +5%)

A/S VESTAS - VINDMØLLEAFDELING
6940 LEM

Sag	23,4 M WINDMILLMAST VESTAS 75 kW / 90 kW	Tegn. nr 90.00
Emne	OVER ALL VIUW	Sag nr 622 Målf 1:75 Dato 01.09.1984
Carl C. Jensen	Thisted & Jørgensen Rådgivende ingeniører F.R.I.	A



ELEVATION, SIDE A

HORIZONTAL DIMENSIONS ARE TO EXTERNAL SIDE OF FLANGES.

ELEVATION, SIDE B

BOLT ASSEMBLINGS:

ALL JOINT BOLTS ARE M 20 WITH WASHERS

AFTER HAVING ASSEMBLED THE MAST WITH COPPER SPANNER AND STRAIGHTENING OUT HAS BEEN DONE, TIGHTENING OF ALL BOLTS HAS TO BE MADEWITH A MOMENT KEY.

MOMENT = 490 Nm (49 kgm)

LACINGS:

No. GIVES LACINGS.

ALL LACINGS ARE TO BE TURNED, SO THAT HORIZONTAL FLANGE IS UP.

VESTAS A/S - VINDMØLLEAFDELING
6940 LEM

REV. DATE 01.12.1984

23,4 M WINDMILLMAST
VESTAS 75 kW / 90 kW

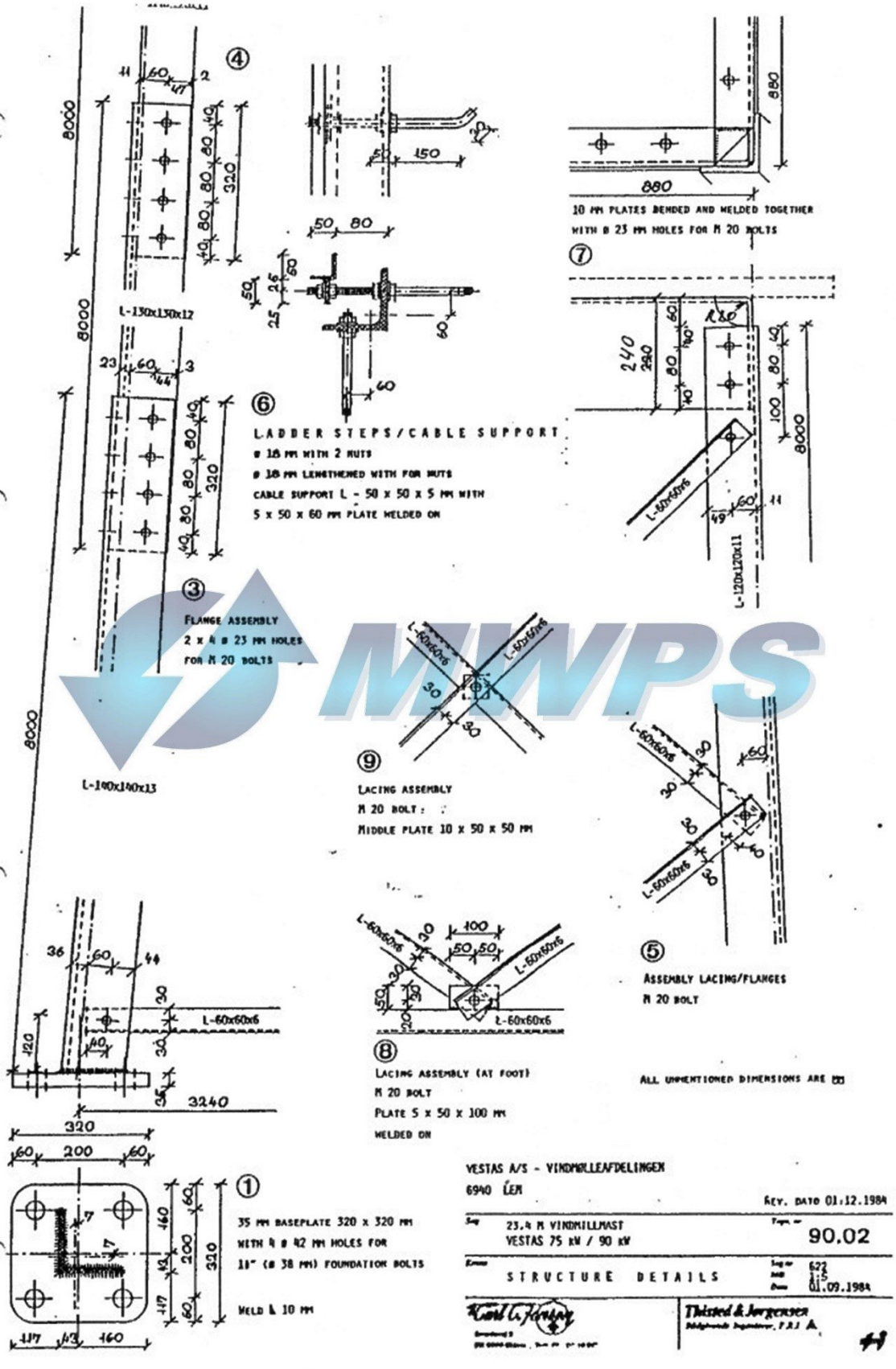
Page no. 90.03

ASSEMBLY DRAWING

Dwg no. 622
Scale 1:62.5
Date 01.09.1984

Carl C. Hansen

Thisted & Jørgensen
Rådgivende ingeniører, F.R.I. A



VESTAS A/S - VINDMØLLEAFDELINGEN
6940 LEM

REV. DATO 01.12.1984

23.4 M VINDMILLEMAST
VESTAS 75 kW / 90 kW

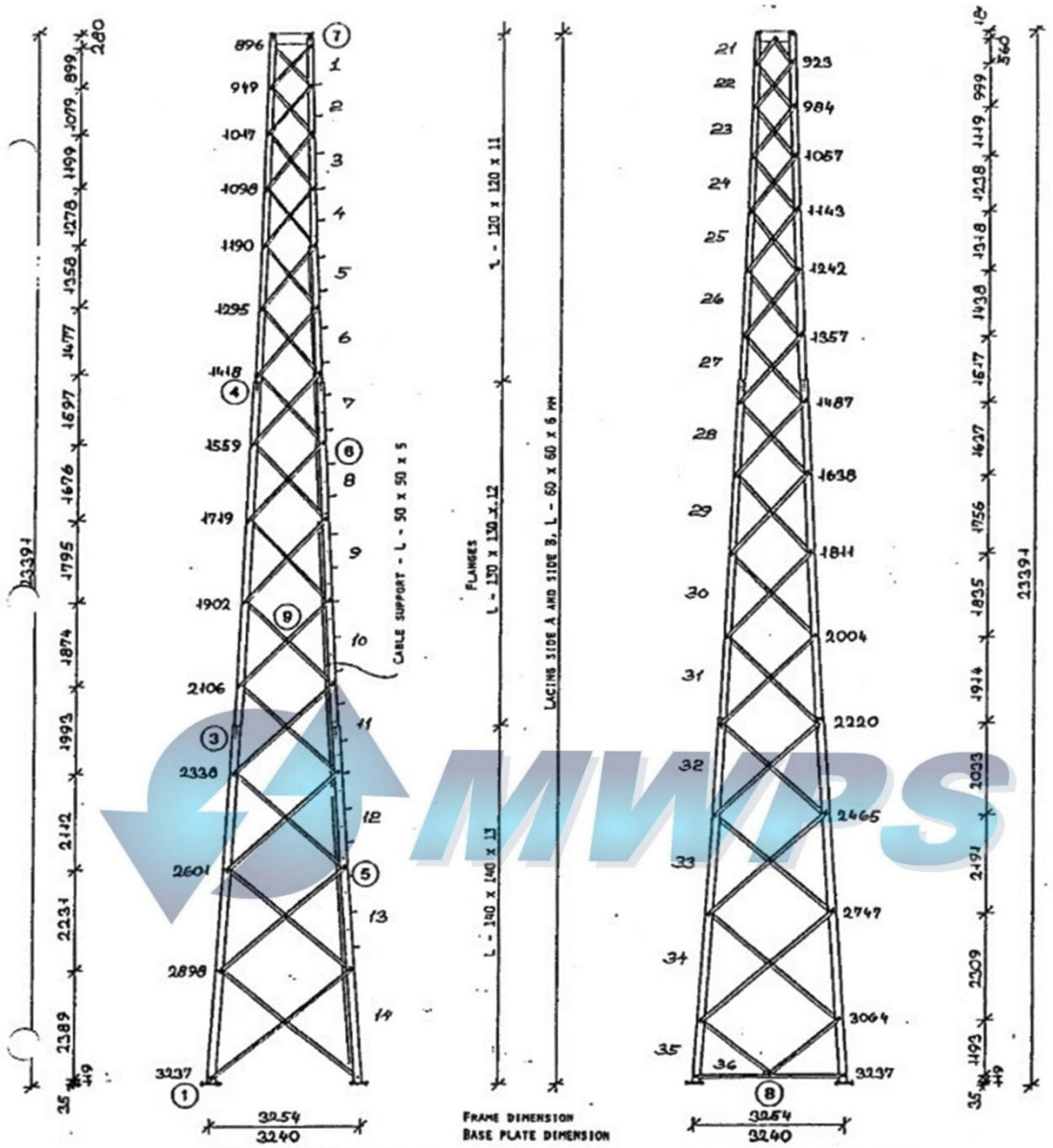
90.02

STRUCTURE DETAILS

622
1:5
01.09.1984

Thisted & Jørgensen
Rådgivende Ingeniører, F.R.I. A.

49



REMARKS

STRUCTURAL DETAILS (1)-(9) SEE DRAWING 90.02

MATERIALS:

ANGLES AND PLATES, ST 37-2, $\sigma_f \geq 240$ N/mm^2

BOLTS, EVERYWHERE M 20, STRENGTH CLASS 8.8

LADDER STEPS M 18, ST 37-2

FOUNDATION BOLTS 4 x 4 18", ST 37-2

ALL UNMENTIONED DIMENSIONS ARE mm

ALL STEEL IS TO BE HOT GALVANIZED

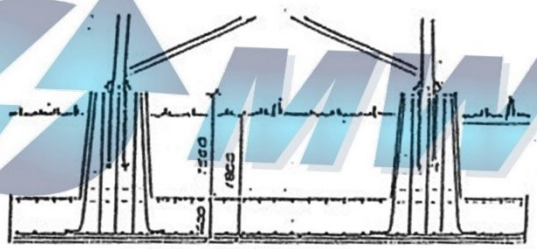
VESTAS A/S VINDMØLLEAFDELINGEN
6940 LEM

Proj.	23,4 M VINDMILLMAST VESTAS 75 kW / 90 kW	Dwg. no. 90.01
Drawn	ELEVATIONS	Proj. no. 622 Scale 1:25 Date 01.04.1989
Carl C. Hansen	Thisted & Jørgensen	A

F O U N D A T I O N F O R

23.4 M WINDMILL TOWER

V E S T A S 90 KW



D R A W I N G S

Date 1984.12.10

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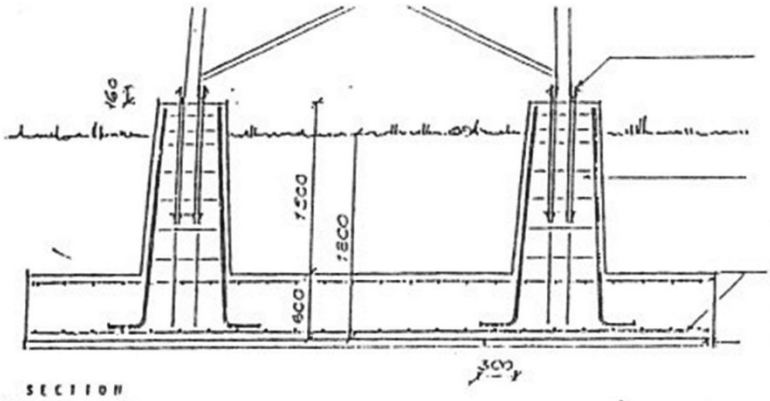
Date

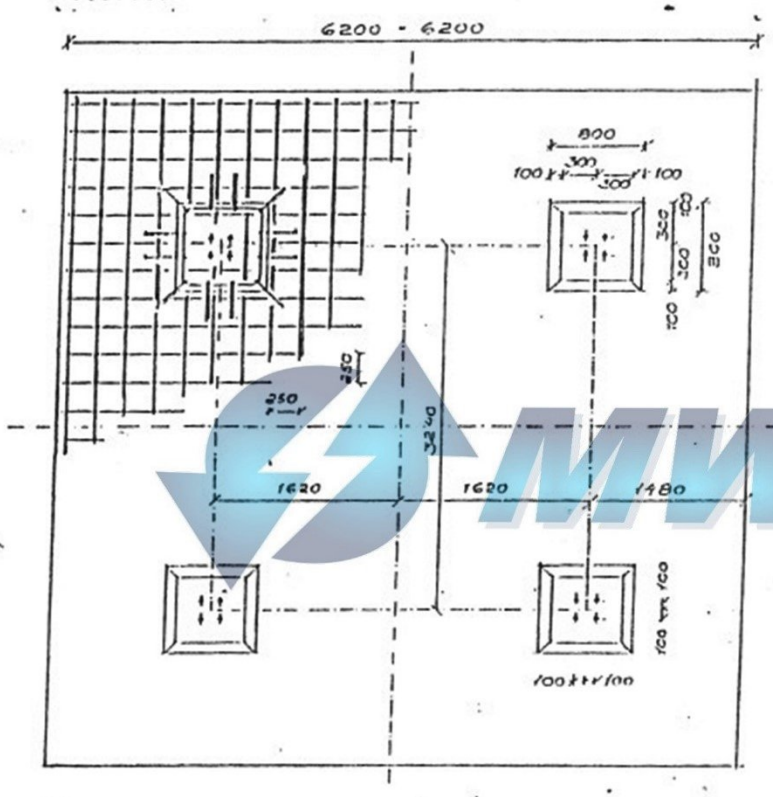


SECTION

4 x 4 1 1/2" foundationbolts, L = 1200 mm
The bolts are to be mounted according to the delivered shape.

Reinforcement in pedestals:
4 x 12 tension IR mesh bending.
Roundbar 7 hoofes pr. 250 mm.

Crosswise reinforcement in plate:
In top tension 10/250 mm.
In bottom tension 14/250 mm.
Cleaning layer 150 mm.



PLAN

Concrete:

Controlclass II
Concrete 20 (β_{ck} = 20 N/mm²).
Slump 30 - 60 mm.
Concrete cover = 50 mm.
The concrete is to be vibrated.

Concretecontrol referring to DS. 411, to secure that the materials and the execution are in accordance with drawings and calculations.

Soil:

Assumptions: Not worser than firm embedded
Fine aggregate $\phi \geq 27°$.
Clay c, $\geq$ 60 kN/m².
Effective soil density = 17 kN/m³.
The ground water level must be below the base of footing.

Soil control referring to DS. 415, to secure soil which is able to support.

The foundation proposal is only to be used when every conditions is fulfilled.

The foundation is to be covered, before the mast is to be erected.

All unmentioned dimentions are mm

The owner assume full responsibility by using the proposal, as all calculations and dimentions are based on estimated soil.

VESTAS A/S VINDMØLLEAFDELING
6940 LEM

Type 25.4M VINDMILLEMAST	Proj. no. 90.04
VESTAS 90 kW	
Name FOUNDATIONPROPOSAL	Type 690.05 Scale 1:50 Date 01.12.1989

Thisted & Jørgensen

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A S S E M B L I N G S P E C I F I C A T I O N

The lattice mast consists of:

4 legs, L - 120 x 120 x 11 mm
4 legs, L - 130 x 130 x 12 mm
4 legs, L - 140 x 140 x 13 mm with baseplates welded on.
116 lattices, L - 60 x 60 x 6 mm
2 spaces , L - 60 x 60 x 6 mm
1 yaw top
3 cable supports, L - 50 x 50 x 6 mm
43 ladder steps R 18
8 ladder steps/cable supports R 18
1 bolt for cable support R 18
250 M 20 x 60 mm assembly bolts with nuts and 4 mm washers
4 M 20 x 70 mm assembly bolts with nuts and 4 mm washers
54 spacers 10 x 50 x 50 mm
16 anchor bolts R 38 mm, 1 1/2" nuts and anchor plates plus anchor bolt jig.

The lattice mast is assembled in horizontal position
On of the mast sides is placed on trestles of variable height.
The outside curve of the tower appears from drawings no. V17.51 and V17.52, whe
the horizontal dimensions are shown.
The trestle heights can be determined from this.

One mastside is horizontal assembled and is aligned after a rope placed above all lattices.
Departure max. ± 10 mm.
Hereafther the other 3 sides are assembled and aligned.
During assembling of the mast the nuts are repeatedly tightened and slacked of to remove burrs or roughness under washers and nuts.

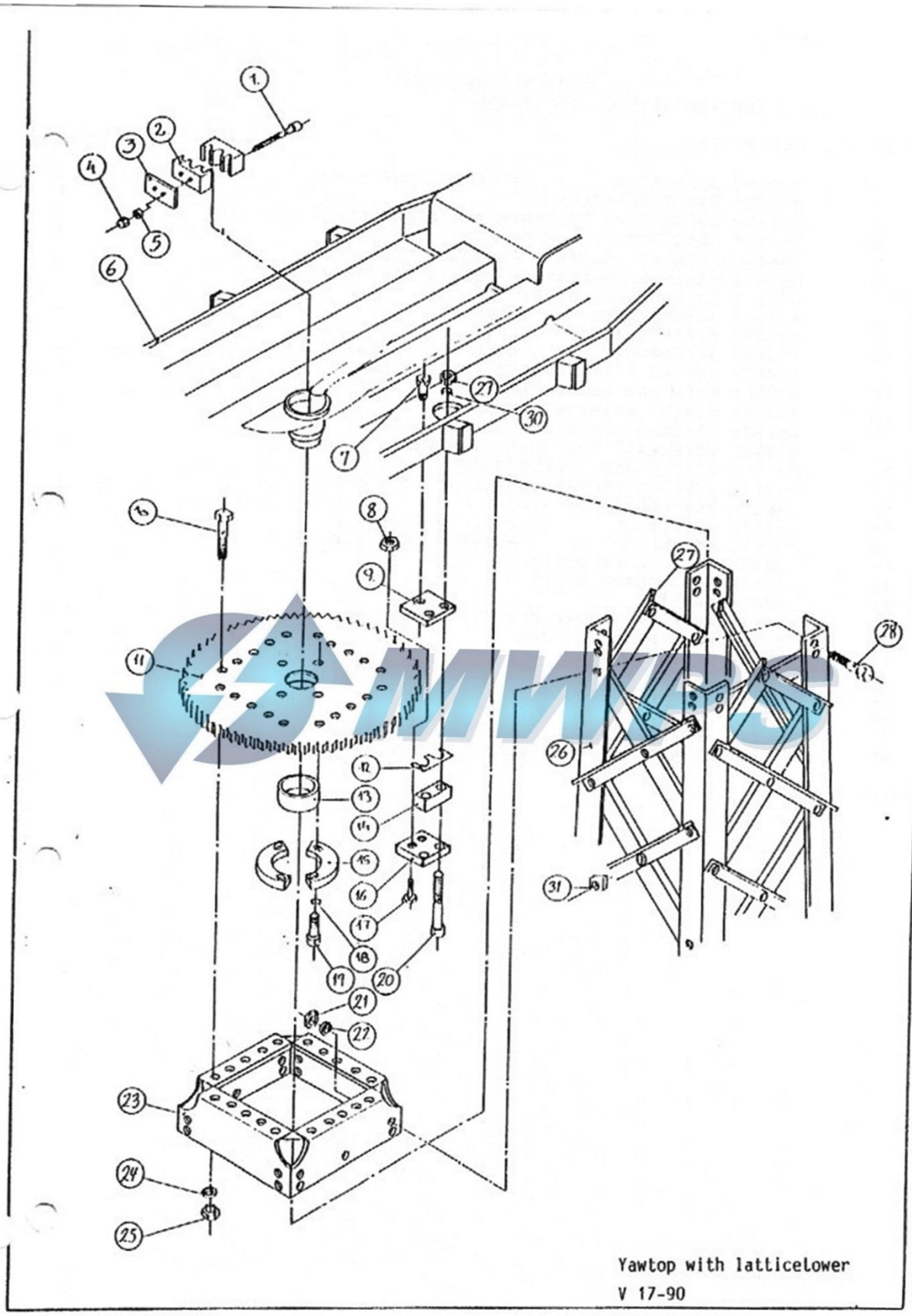
All assembly bolts are M 20 of quality 8.8.
For each is used 2 washers of thickness 4 mm.
1 washer is used under the bolt head and 1 washer is used under the nut.
Do not use other bolts than the enclosed.
When the whole mast is assembled and aligned, all assembly bolts must be tigh up with a torque wrench.
Tightening torque = 490 Nm (49 kgm) for M 20 bolts.

This teightening is very important to resist the dynamic loads on the mast.
Therefore an effective control must ensure that all bolts are teightened up.
The control must consist of a 5% sample of all bolts in the mast.
If any faults of the tightening appears, a 100% control mus be performed.
In case a 100 % control cannot be carried through it is recommended, as a further security, to lock all bolts with a centre punch or secure them with "Loctite superfast 270" nut lock.

When the mast is erected it must be secured that the mast top centre does not diverge more than ± 50 mm from vertical.
Furthermore it must be secured that no lattices during transport or erection have been bended or in other way deformed.

Deformed legs and web members must be renewed before the turbine is started up.

It is recommended, at convenient intervals, possibly in connection with service on the turbine, to perform a visual check-up on the mast construction. Spot tests of the bolt tightening must be performed.
In case any faults are found a 100% tightening up must be carried out.



Yawtop with latticeLower

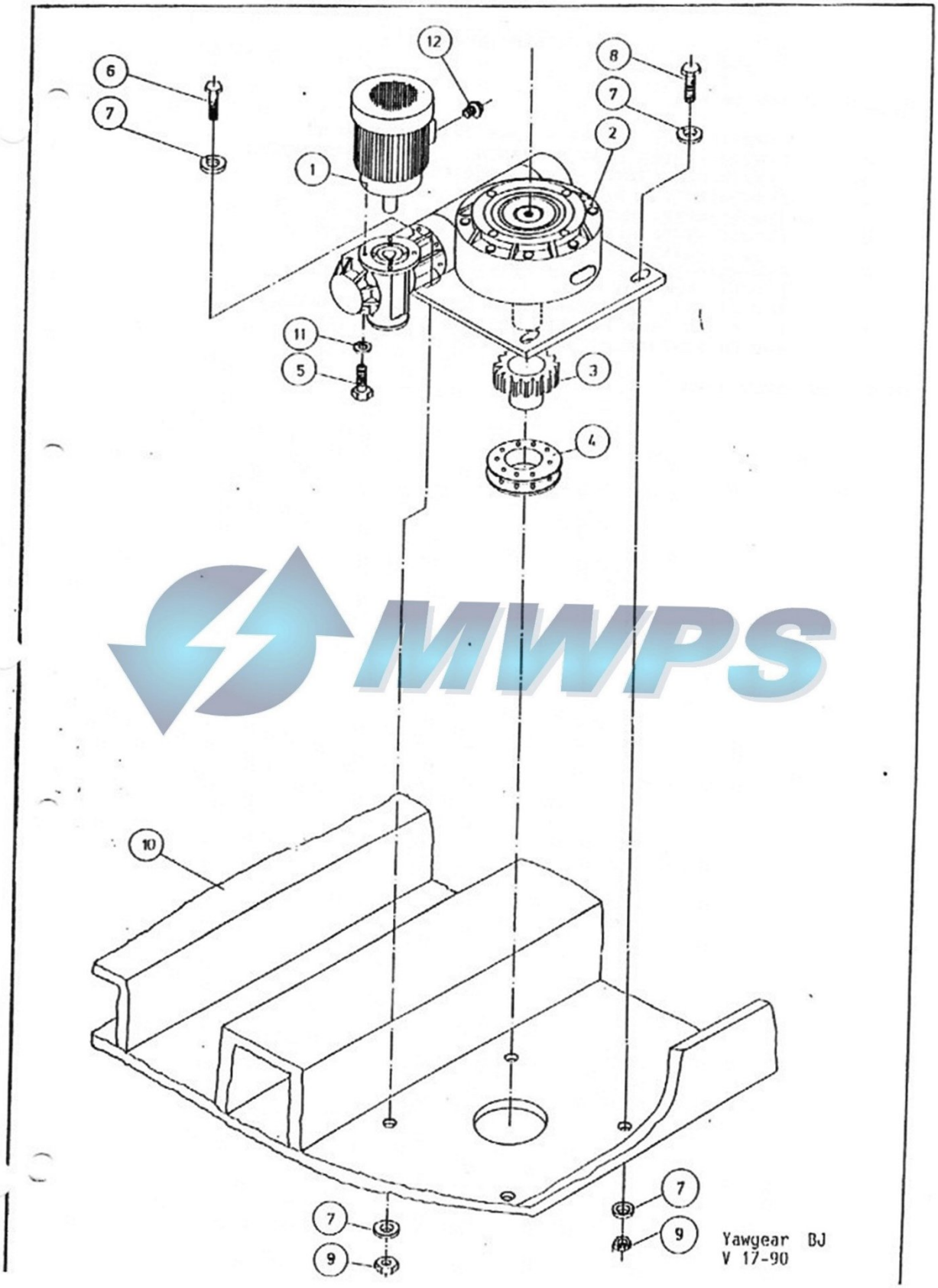
V 17-90

VESTAS ENERGY A/S

YAW-TOP WITH LATTICETOWER V 17-90

I NR	EDB NR	ENG	DIV	ANTAL
1	152005	STEELBOLT M 8x100 FZB 8:8		2
2	862711	CABLE UNLOADER		1
3	877360	HOLDING PLATE CABLE RELIEF DEVICE		1
4	157724	LOCK NUT M 8 FZB		2
5	156663	BEVELED WASHER ø 8.40xø17.00x1.60		2
6	861553	MASHINE FOUNDATION, READY FOR MOUNTING		1
7	877271	GUIDE BOLT SLIDE BEARING		3
8	157066	HEXAGON NUT M20 GALV.		6
9	862371	SLIDE BEARING OILON		3
10	153451	STEELBOLT M20x 80 FZB 8:8		20
11	878138	YAWING PLATE (HOLES IN SQUARE)		1
12	877891	SHIM FOR GRIP PLATE		3
13	872741	CENTER BEARING FOR 30MM		1
14	862835	SPACING PIECE FOR SLIDE BEARING		3
15	878677	UNDERPART FOR HOLD RING CENT.		1
16	862843	GRIP PLATE, SLIDE SHOE		3
17	153990	STEEL SETSCREW M20x100 FZB 8:8		6
18	156256	BEVELEDWASHER ø10,5		4
19	154199	STEELBOLT M10x 40 FZB 8:8		4
20	153079	STEELBOLT M24x150 FZB 8:8		6
21	90468	BOX, JOINT BOLTS		0
22	90468	BOX, JOINT BOLTS		0
23	90379	YAW TOP		1
24	156469	BEVELED WASHER ø21.00xø37.00x3.00		20
25	157619	LOCK NUT M20		20
26	90387	SECT. 1 EDGER TOP		4
27	90425	GRATE, SET		0
28	90468	BOX, JOINT BOLTS		0
29	157600	LOCK NUT M24 FZB 8		6
30	156639	BEVELED WASHER ø25.00xø44.00x4.00		6
31	871591	SQUARE WASHER (COLLI FITTINGS F. 1 90KW)		0

Poster udskrevet = 31



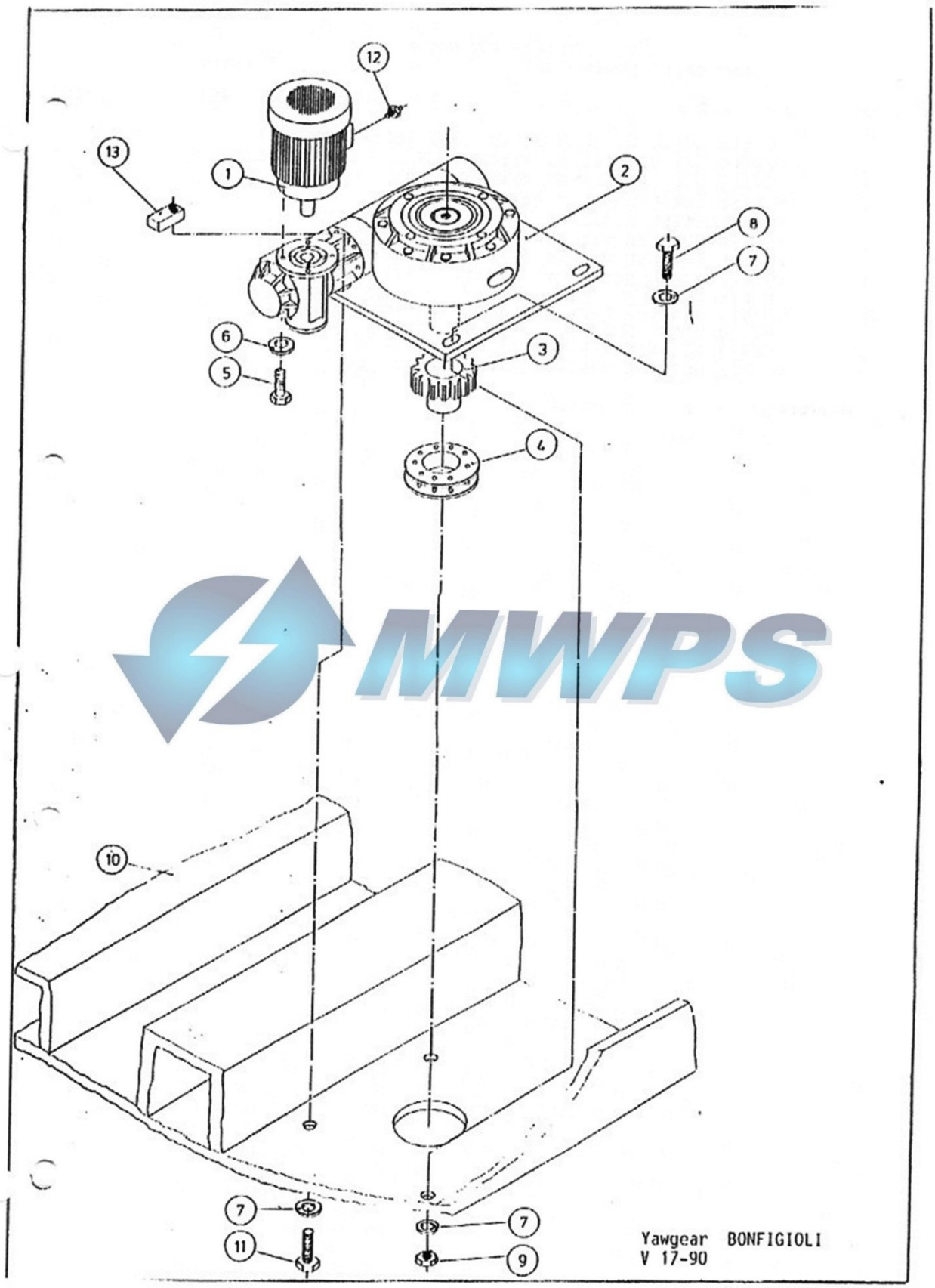
Yawgear BJ
V 17-90

VESTAS ENERGY A/S

YAW-GEAR BJ V 17-90

S NR	EDB NR	ENG	DIV	ANTAL
1	93614	MOTOR MG 80A4-14F85 2270 480V 60HZ		1
2	115410	YAWING GEAR BJ-VESTAS 1:900 / BONFOGIOLI		1
3	86363	GEAR WHEEL FOR YAWING GEAR		1
4	104450	SHRINK DISC SD68-72		1
5	154261	STEEL SETSCREW M 6x 16 FZB 8:8		4
6	154237	STEEL SETSCREW M16x 45 FZB 8:8		1
7	156817	BEVELED WASHER ø17.00xø30.00x3.00		8
8	152170	STEEL SETSCREW M16*50 10:9		3
9	157755	LOCK NUT M16 FZB 10		4
10	861553	MASHINE FOUNDATION, READY FOR MOUNTING		1
11	156558	BEVELED WASHER ø6.40xø12.50x1.60		4
12	194450	SCREWED CONNECTION PG 16 252/16		1

Poster udskrevet = 12



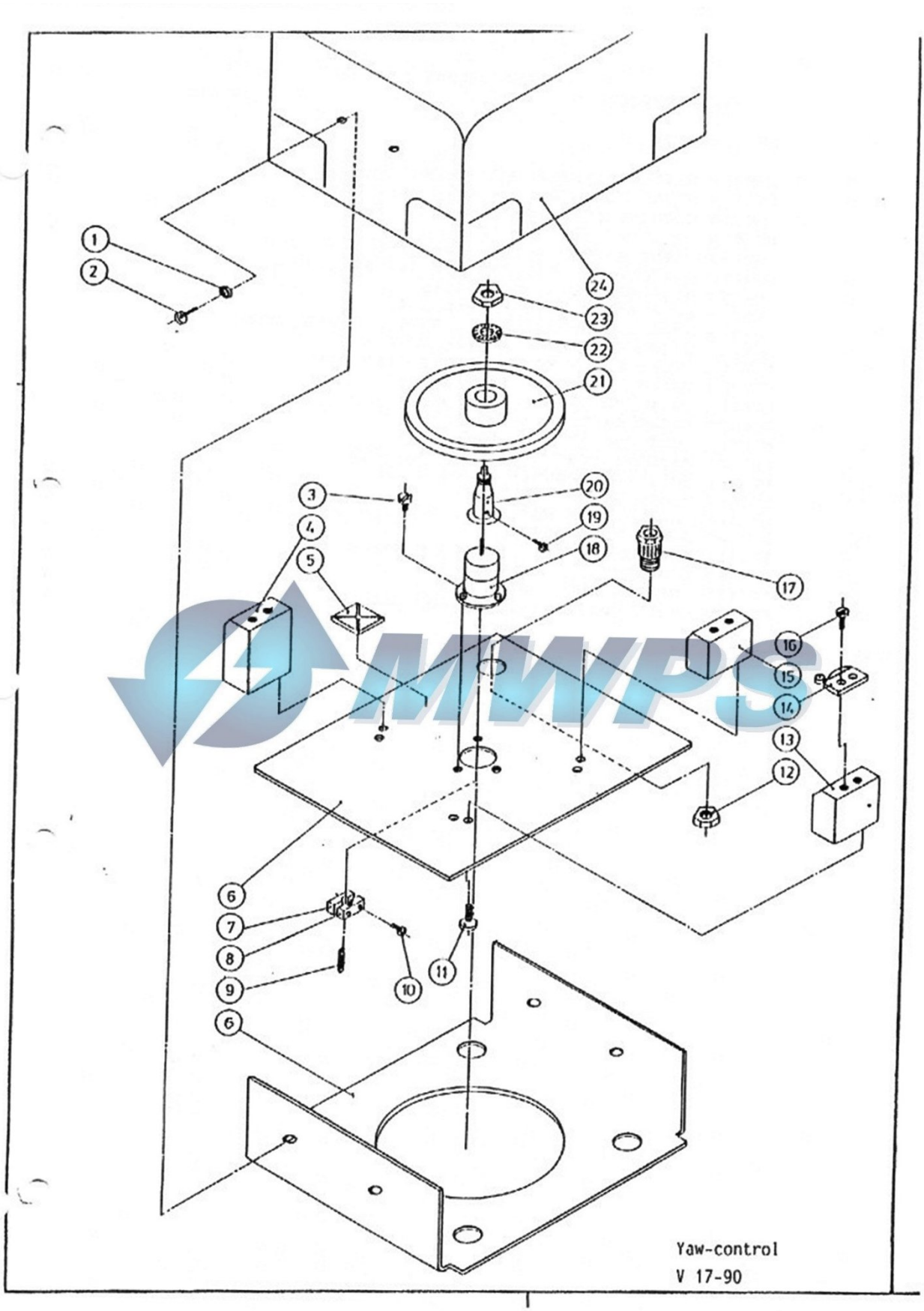
Yawgear BONFIGIOLI
V 17-90

VESTAS ENERGY A/S

YAW-GEAR BONFOGIOLI V 17-90

POS NR	EDB NR	ENG	DIV	ANTAL
1	93614	MOTOR MG 80A4-14F85 2270 480V 60HZ		1
2	115410	YAWING GEAR BJ-VESTAS 1:900 / BONFOGIOLI		1
3	86363	GEAR WHEEL FOR YAWING GEAR		1
4	104450	SHRINK DISC SD68-72		1
5	154261	STEEL SETSCREW M 6x 16 FZB 8:8		4
6	156558	BEVELED WASHER ø6.40xø12.50x1.60		4
7	156817	BEVELED WASHER ø17.00xø30.00x3.00		5
8	152170	STEEL SETSCREW M16*50 10:9		2
9	157755	LOCK NUT M16 FZB 10		2
10	861553	MASHINE FOUNDATION, READY FOR MOUNTING		1
11	152170	STEEL SETSCREW M16*50 10:9		1
12	194450	SCREWED CONNECTION PG 16 252/16		1
13	867420	NUT FOR YAWING GEAR BONFOGIOLI		1

Poster udskrevet = 13



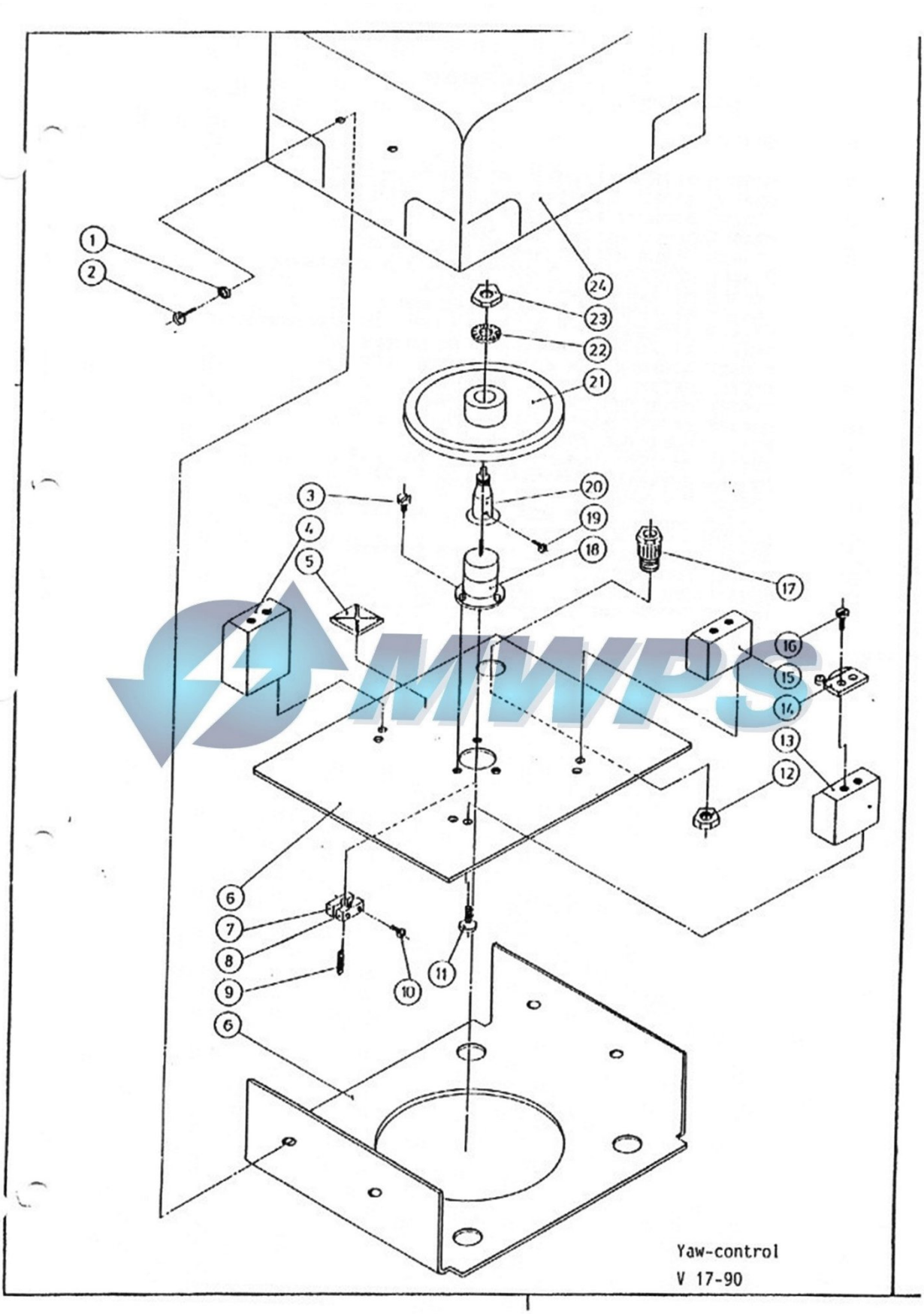
Yaw-control
V 17-90

VESTAS ENERGY A/S

YAW-CONTROL V 17-90

S NR	EDB NR	ENG	DIV	ANTAL
1	156051	BEVELED WASHER ø5.30xø10.00x1.00		4
2	153117	STEEL SETSCREW M 5x10 FZB 8:8		4
3	158356	MACHINE SCREW CHJ M 3x 6 FZB		3
4	874868	FOOT FOR SWITCH, HIGH		1
5	115541	CABLE BINDER HOLDER ABMM-A-D		4
6	873969	UNDERFRAME, PAINTED, US YAWING CONTROL		1
7	86207	RETAINER FITTING, THREAD		1
8	86215	RETAINER FITTING, FREE FIT		1
9	134414	PRESSURE SPRING 0.7x3.6x27 27V RUSTPROOF		1
10	158216	MACHINE SCREW CHJ M 4x 12 FZB		2
11	151025	ALLEN SCREW MC M 5x 12 FZB 8:8		6
12	194379	UNION PG 11 EL 1420/11		1
13	874841	FOOT FOR SWITCH, MIDIUM		1
14	114898	MICRO SWITCH 1052.4201		3
15	874833	FOOT FOR SWITCH, LOW		1
16	158437	MACHINE SCREW CHJ M 2x 10 FZB		6
17	194484	SCREWED CONNECTION PG 11 EL		1
18	115630	MICRO GEAR 135:1		1
19	153028	ALLEN SCREW MSP M 3x 4 FZB 8:8		1
20	874906	CONNECTING SHAFT		1
21	874914	SCANNER WASHER, YAWING CONTROL		1
22	156949	SPROCKET M10 FZB A		1
23	157465	COUNTER NUT M10 FZB		1
24	115479	COVER FOR YAWING CONTROL (PLAST)		1

Poster udskrevet = 24



Yaw-control
V 17-90

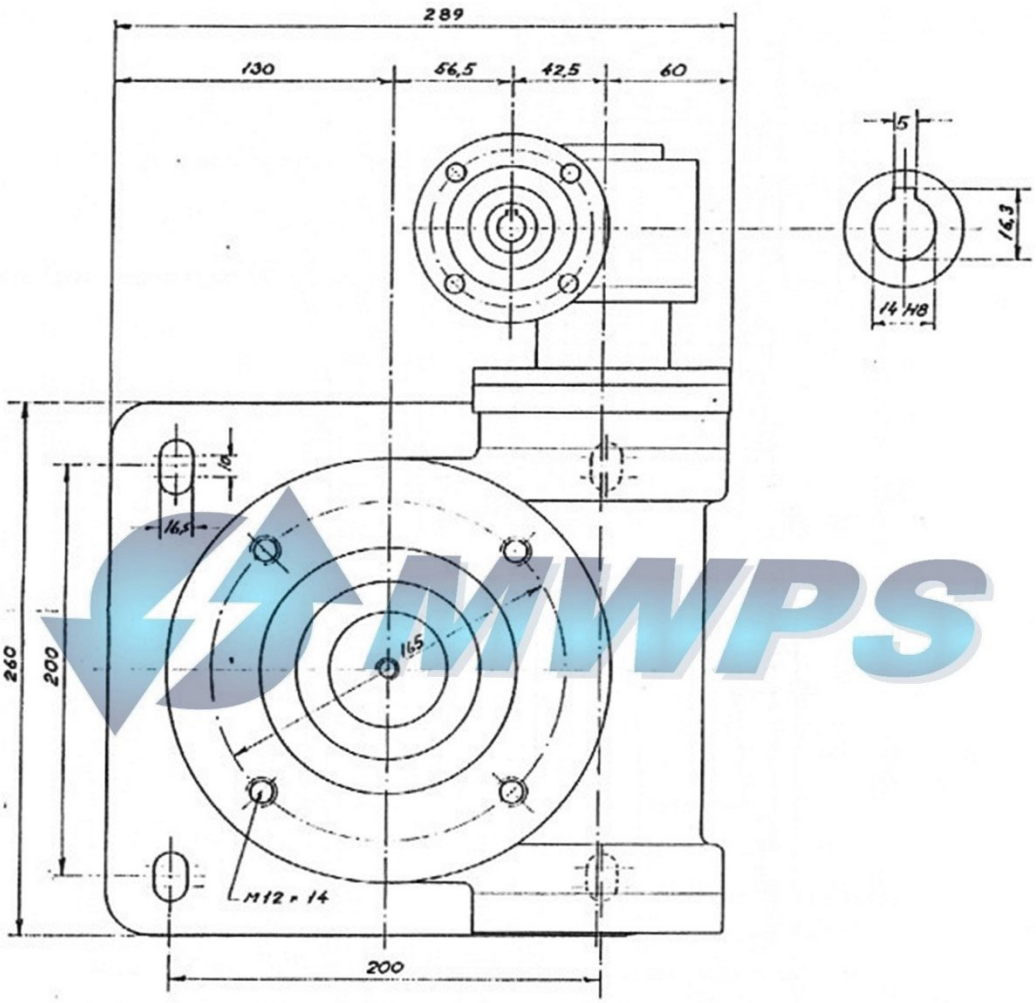
VESTAS ENERGY A/S

YAW-CONTROL V 17-90

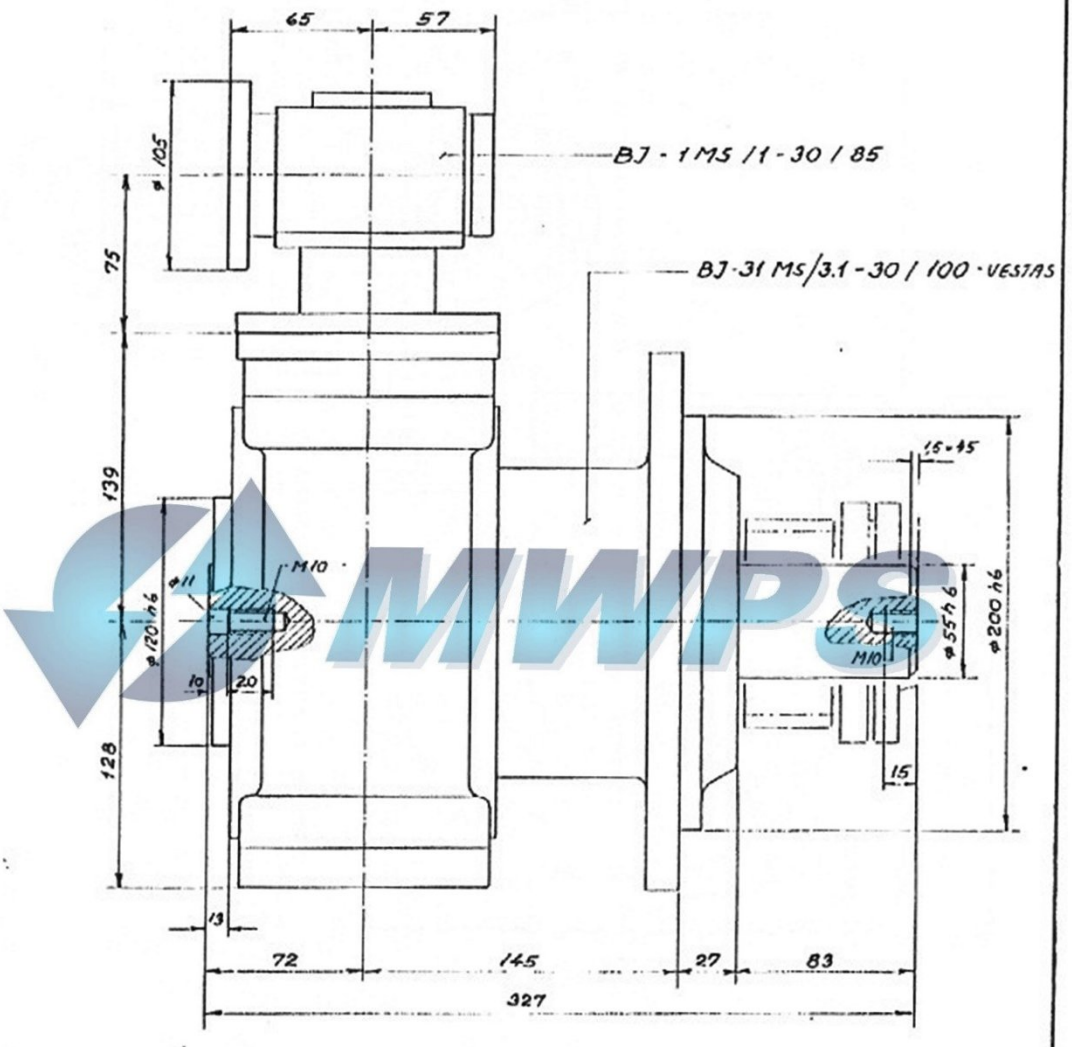
S NR	EDB NR	ENG	DIV	ANTAL
1	156051	BEVELED WASHER ø5.30xø10.00x1.00		4
2	153117	STEEL SETSCREW M 5x10 FZB 8:8		4
3	158356	MACHINE SCREW CHJ M 3x 6 FZB		3
4	874868	FOOT FOR SWITCH, HIGH		1
5	115541	CABLE BINDER HOLDER ABMM-A-D		4
6	873969	UNDERFRAME, PAINTED, US YAWING CONTROL		1
7	86207	RETAINER FITTING, THREAD		1
8	86215	RETAINER FITTING, FREE FIT		1
9	134414	PRESSURE SPRING 0.7x3.6x27 27V RUSTPROOF		1
10	158216	MACHINE SCREW CHJ M 4x 12 FZB		2
11	151025	ALLEN SCREW MC M 5x 12 FZB 8:8		6
12	194379	UNION PG 11 EL 1420/11		1
13	874841	FOOT FOR SWITCH, MIDIUM		1
14	114898	MICRO SWITCH 1052.4201		3
15	874833	FOOT FOR SWITCH, LOW		1
16	158437	MACHINE SCREW CHJ M 2x 10 FZB		6
17	194484	SCREWED CONNECTION PG 11 EL		1
18	115630	MICRO GEAR 135:1		1
19	153028	ALLEN SCREW MSP M 3x 4 FZB 8:8		1
20	874906	CONNECTING SHAFT		1
21	874914	SCANNER WASHER, YAWING CONTROL		1
22	156949	SPROCKET M10 FZB A		1
23	157465	COUNTER NUT M10 FZB		1
24	115479	COVER FOR YAWING CONTROL (PLAST)		1

Poster udskrevet = 24

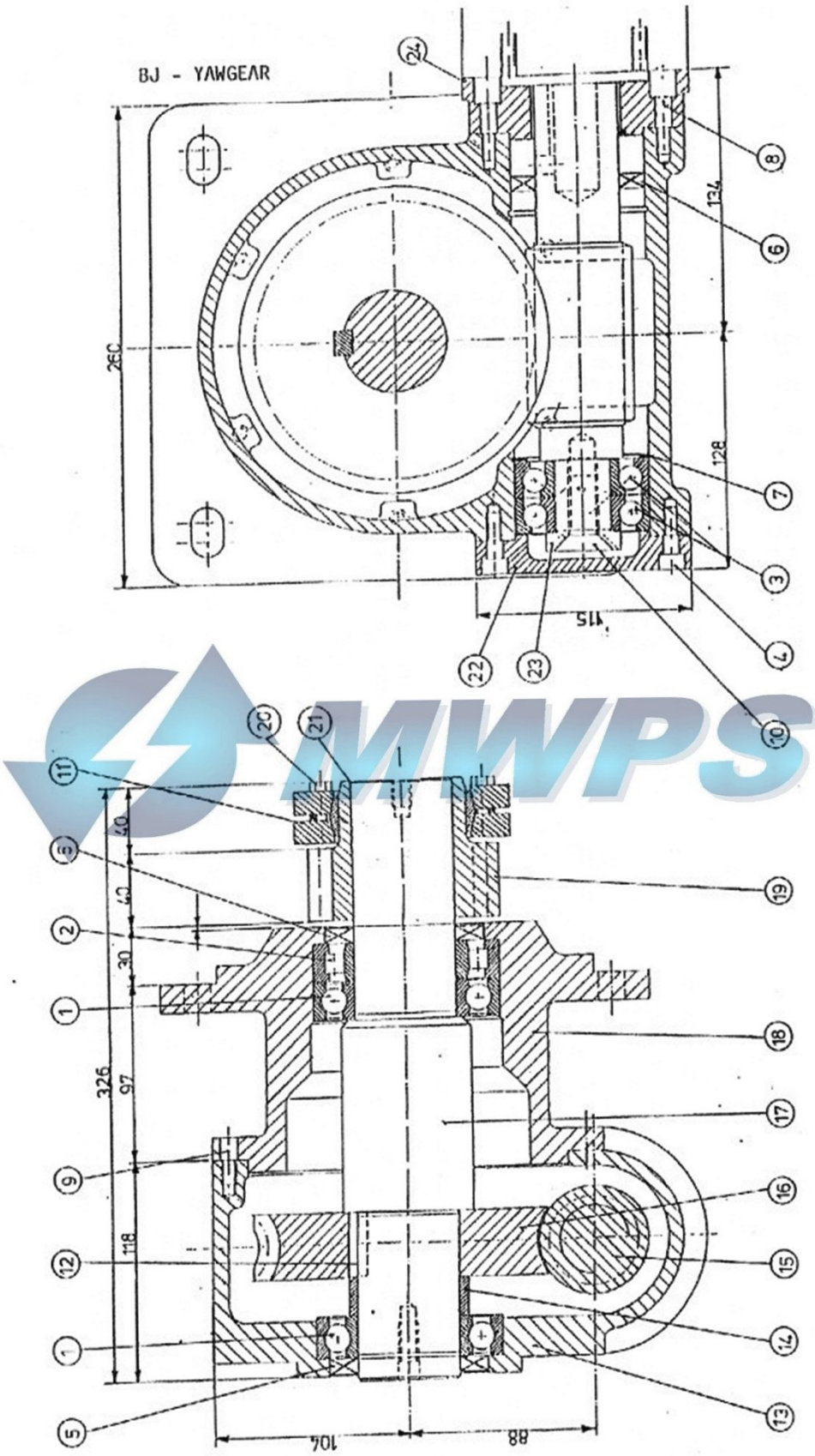
BJ YAWGEAR



Lubrication: Thermac 710
Transmitted torque 900 Nm
Transmission ratio I 30:1
Transmission ratio II 30:1



BJ YAWGEAR


BJ - YAWGEAR
260
134
128
115
326
97
118
104
88

BJ - YAWGEAR

1	SKF bearing 6211-2RS
2	SKF bearing NU 211
3	SKF bearing 7306 B
4	Allen screw M8x20
5	Stuffing box 85x55x10
6	Stuffing box 72x43x08
7	Lock ring
8	Allen screw M8x30
9	Allen screw M8x20
10	Mach. screw M16x40
11	Shrink element
12	Key 16x10x35
13	Gearhouse
14	Distance ring
15	Hole worm
16	Worm wheel
17	Output shaft
18	Output flange
19	Pinion wheel
20	Torque 42 Nm
21	Grease free surface
22	Inner cap
23	Lock washer
24	Motor flange

BONFIGLIOLI YAWGEAR

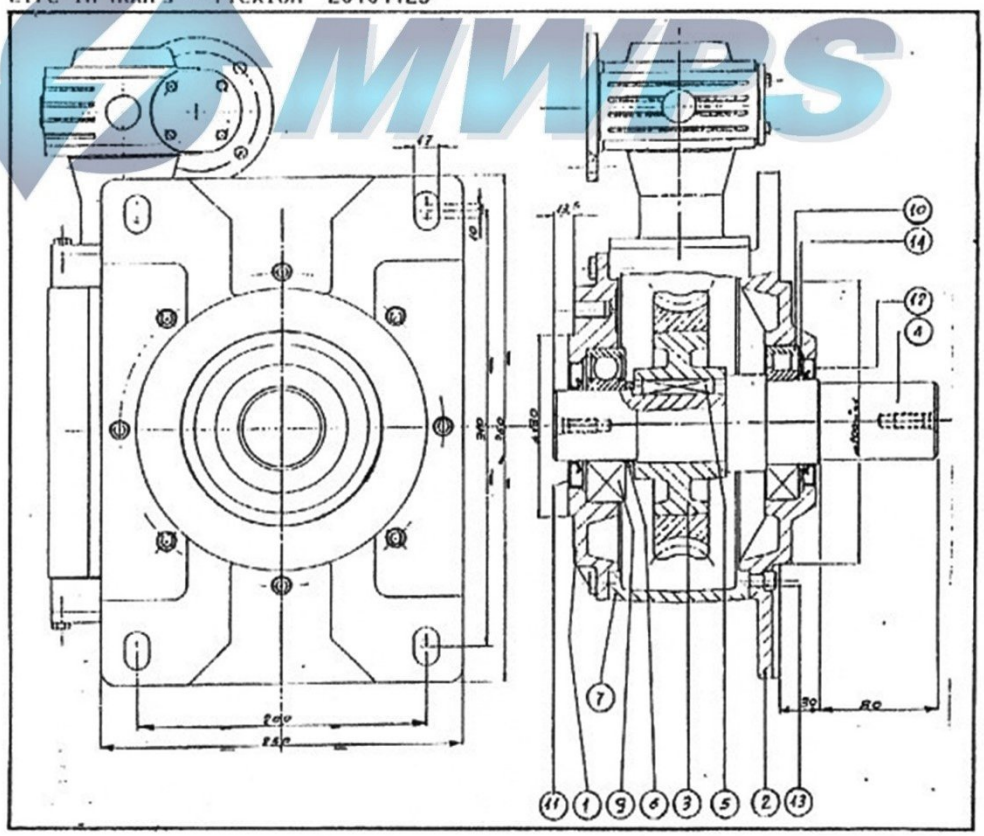
MVF49/110 RQ VESTAS Ratio 1:840

Checking on the wormwheel VF110 ratio 1/30 - According b.s. 721

Center distance mm 110.1
Pitch diameter wormshaft mm 46.83
Pitch diameter wormwheel mm 173.36
Standard module 5.73528
Wheel band mm 38
Material of the wheel B14
Limit voltage (N/mm²) 27.5
Resistance factor (N/mm²) 60

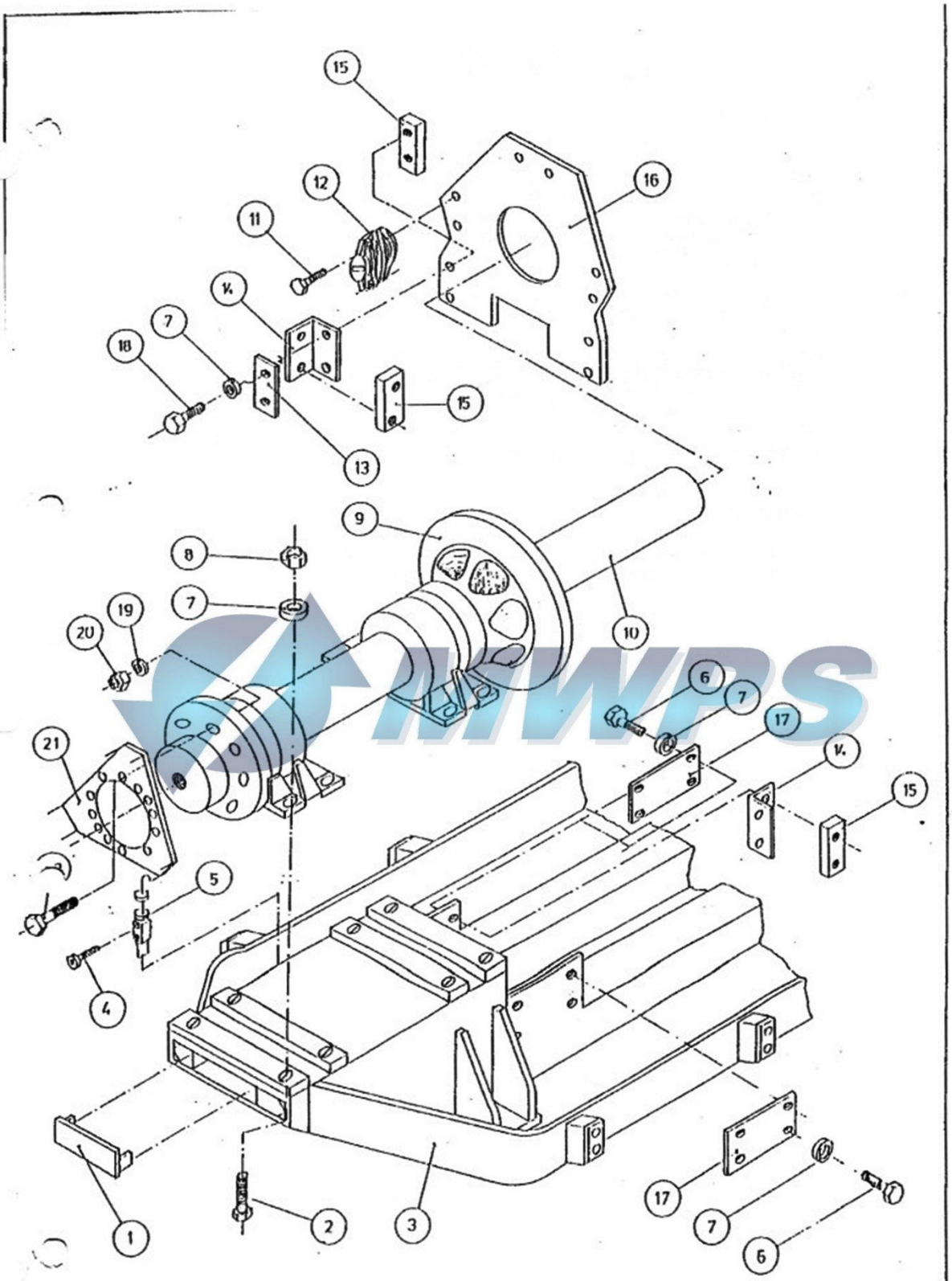
RPM wheel 1.6
S.F. 1
Transmitted torque (Nm) 1100

Life in hours - wear 33289
Life in hours - flexion 20164123



BONFIGLIOLI YAWGEAR

1	End cap
2	Output flange
3	Worm whell 1:30
4	Output shaft
5	Key 16x10x50
6	Distance ring
7	Gear house
9	Bearing 50x110x22
10	Bearing 60x110x22
11	Stuffing box 50x90x10
12	Stuffing box 60x90x8
13	Allen screw M8x25
14	Lock ring



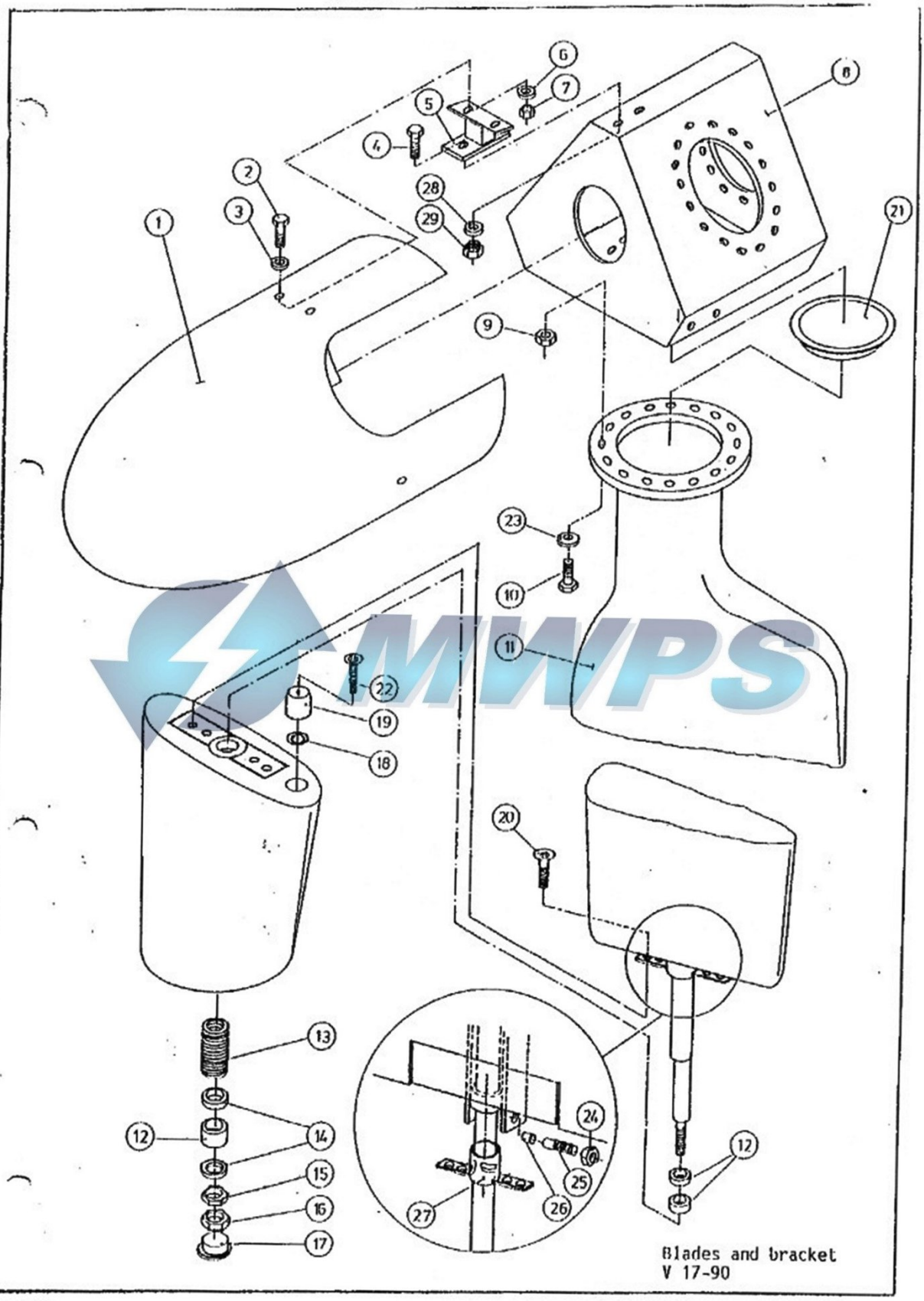
Shaft- and bearing arrangem.
V 17-90

VESTAS ENERGY A/S

SHAFT AND BEARING ARRANGEMENT V 17-90

NR	EDB NR	ENG	DIV	ANTAL
1	875619	TIGHTENING PLATE MACHINE FOUNDATION		1
2	152358	STEELBOLT M24x100 FZB 8:8		8
3	861553	MASHINE FOUNDATION, READY FOR MOUNTING		1
4	151246	ALLEN SCREW MC M 4x 40 FZB		2
5	863408	VIBRATION SENSOR WITH WEIGHT BLOCK		1
6	154440	STEEL SETSCREW M24x 55 FZB 8:8		8
7	156639	BEVELED WASHER ø25.00xø44.00x4.00		20
8	157600	LOCK NUT M24 FZB 8		8
9	863106	SHAFT-BEARING ARRANGEMENT		1
10	864005	MAIN SHAFT		1
11	152129	STEEL SETSCREW M20x 50 FZB 8:8		6
12	863475	BRAKE CALIBRE (type: 280231-70A)		3
13	866814	SHIM, WITH 2 H., CUT		2
14	867071	FITTING FOR BRAKE SUSPENSION		4
15	866970	THREAD PLATE FOR FASTENING		6
16	867101	SUSPENSION FOR BRAKE CALIBRE		1
17	866822	SHIM, WITH 4 H., CUT		2
18	155349	STEEL SETSCREW M24 * 70		4
19	155969	WASHER ø 25* ø 45* 4 HB 200		10
20	157600	LOCK NUT M24 FZB 8		10
21	864781	WING BRACKET DRILLED V15/17		1
22	152137	STEELBOLT M24x120 GALV. 8:8		10

Poster udskrevet = 22



Blades and bracket
V 17-90

VESTAS ENERGY A/S

BLADE AND BRACKET V 17-90

NR	EDB NR	ENG	DIV	ANTAL
1	862762	SPINNER, DRILLED		1
2	152498	STEEL SETSCREW M12x 30 FZB 8:8		6
3	897329	WASHER Ø34xØ13x3		6
4	154385	STEELBOLT M16x 60 FZB 8:8		6
5	862649	FITTING FOR SPINNER		3
6	156833	BEVELED WASHER Ø13.00xØ24.00x2.50		6
7	157775	LOCK NUT M12 FZB		6
8	864781	WING BRACKET DRILLED V15/17		1
9	157317	HEXAGON NUT M20 FZB 8:8		48
10	153443	STEELBOLT M20 * 70 FZB 8:8		48
11	860905	BLADE VESTAS 8.5M		3
12	898880	DISTANCE BUSHING 5MM		0
12	898899	DISTANCE BUSHING 6MM		0
12	898902	DISTANCE BUSHING 7MM		0
12	898910	DISTANCE BUSHING 8MM		0
12	898929	DISTANCE BUSHING 9MM		0
12	898937	DISTANCE BUSHING 24MM		0
12	898945	DISTANCE BUSHING 29MM		0
12	898953	DISTANCE BUSHING 34MM		0
12	898961	DISTANCE BUSHING 39MM		0
12	898988	DISTANCE BUSHING 44MM		0
13	134821	PRESSURE SPRING Ø12xØ53x410 FZB		3
14	897256	WASHER Ø54xØ20.5x3 RUSTPROOF		6
15	158038	HEXAGON NUT M20 BRASS		3
16	158046	LOCK NUT M20 RUSTPROOF		3
17	149225	PLAST PLUG GLI60		3
18	158765	WASHER NYLON Ø20 * Ø38 * 3		1
18	158769	WASHER NYLON Ø20 * Ø38 * 4		0
18	158785	WASHER NYLON Ø20 * Ø38 * 5		0
19	149225	PLAST PLUG GLI60		3
20	151033	ALLEN SCREW MK M 8x 20 RUSTPROOF		12
21	88323	COVERING, WINGROOT		3
22	151878	ALLEN SCREW MK M 6x 35 A4 NON CORROSI		3
23	156370	WASHER ST4.6 Ø25.0xØ58.0x7.0		48
24	158054	LOCK NUT M16 RUSTPROOF		6
25	898694	GUIDE BOLT M16 OKAER		6
26	898708	HARDENED STEEL BUSHING Ø16.2 OKAER		0
26	898864	HARDENED STEEL BUSHING Ø16.5 OKAER		0
26	898872	HARDENED STEEL BUSHING Ø16.8 OKAER		0
27	897132	PIPE WITH GUIDE FACING, WELDED		3
28	156817	BEVELED WASHER Ø17.00xØ30.00x3.00		6
29	157759	LOCK NUT M16 FZB		6

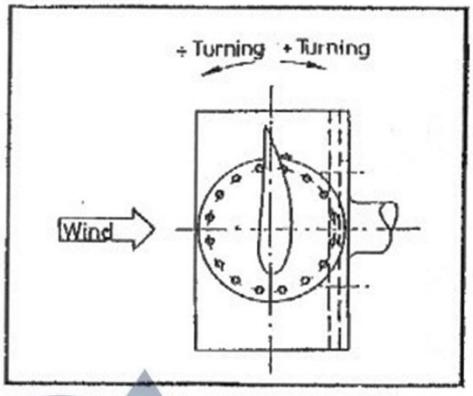
Poster udskrevet = 42

Vestas

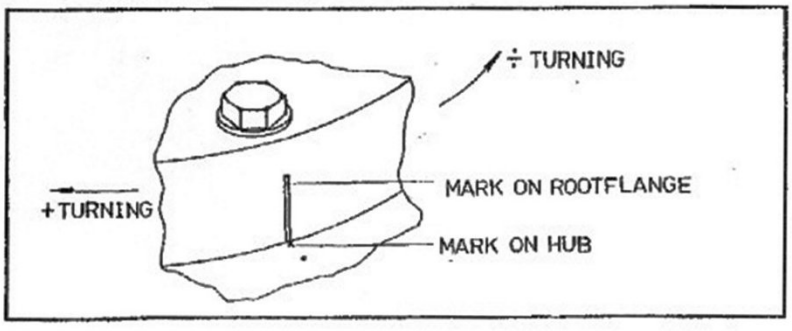
Mounting of blades

Blades 8,5 m

Clean the root flange for old paint and roughness before mounting the blades.



Mount the blades on the hub with M24 bolts. Do not tighten the bolts more than it is possible to turn the blades.
Before tightening the bolts, turn the blades so the tip angle is on the wanted value (acc. to page
Contact Vestas service department if there should be any reason the change the tip angle.
1^{o} = 4,2 mm on the bladerootflange.



Adresse: VESTAS ENERGY A/S POSTBOX 42 DK 6940 LEM DENMARK
Telefon: + 45 - 7 - 341188
Telex: 60733 VESTAS DK
Telefax: + 45 - 7 - 341484
Postgiro: 1588508
Bank: A/S RINGKØBING BANK 7650-200716-4 DEN DANSKE BANK
A/S reg. nr.: 65903

Vestas

Mounting of blades

Tighten the bolts in numerical order 1-16 (fig. 1). Tighten the bolts stepwise, 30° at the time, and still in numerical order untill the bolts are tightened with the prescribed torque.

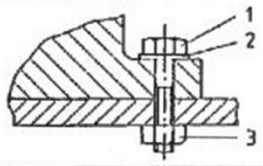
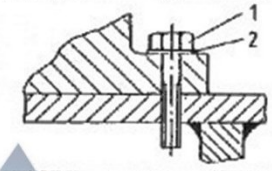
Pos. 2-4 6-8 10-15		1 : 668 Nm 3 : 668 Nm
Pos. 9 og 16		1 : 668 Nm
Pos. 1 og 5		1 : 668 Nm

Fig. 2

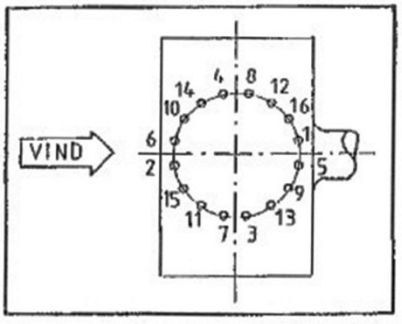


Fig. 1

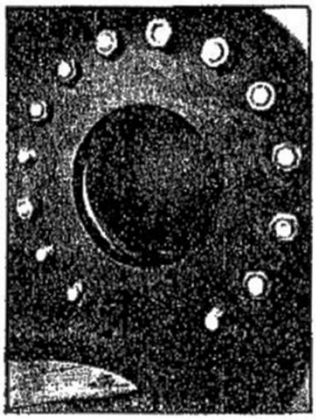


Fig. 3

Tighten the counter nut on the inside next, and at the same torque as the bolts.
Torque = 668 Nm.

Adresse: VESTAS ENERGY A/S POSTBOX 42 DK 6940 LEM DENMARK

Telefon: + 45-7-341188

Telex: 60733 VESTAS DK

Telefax: + 45-7-341464

Postgiro: 1588508

Bank: A/S RINGKØBING BANK 7650-200716-4 DEN DANSKE BANK 3403-14700-1

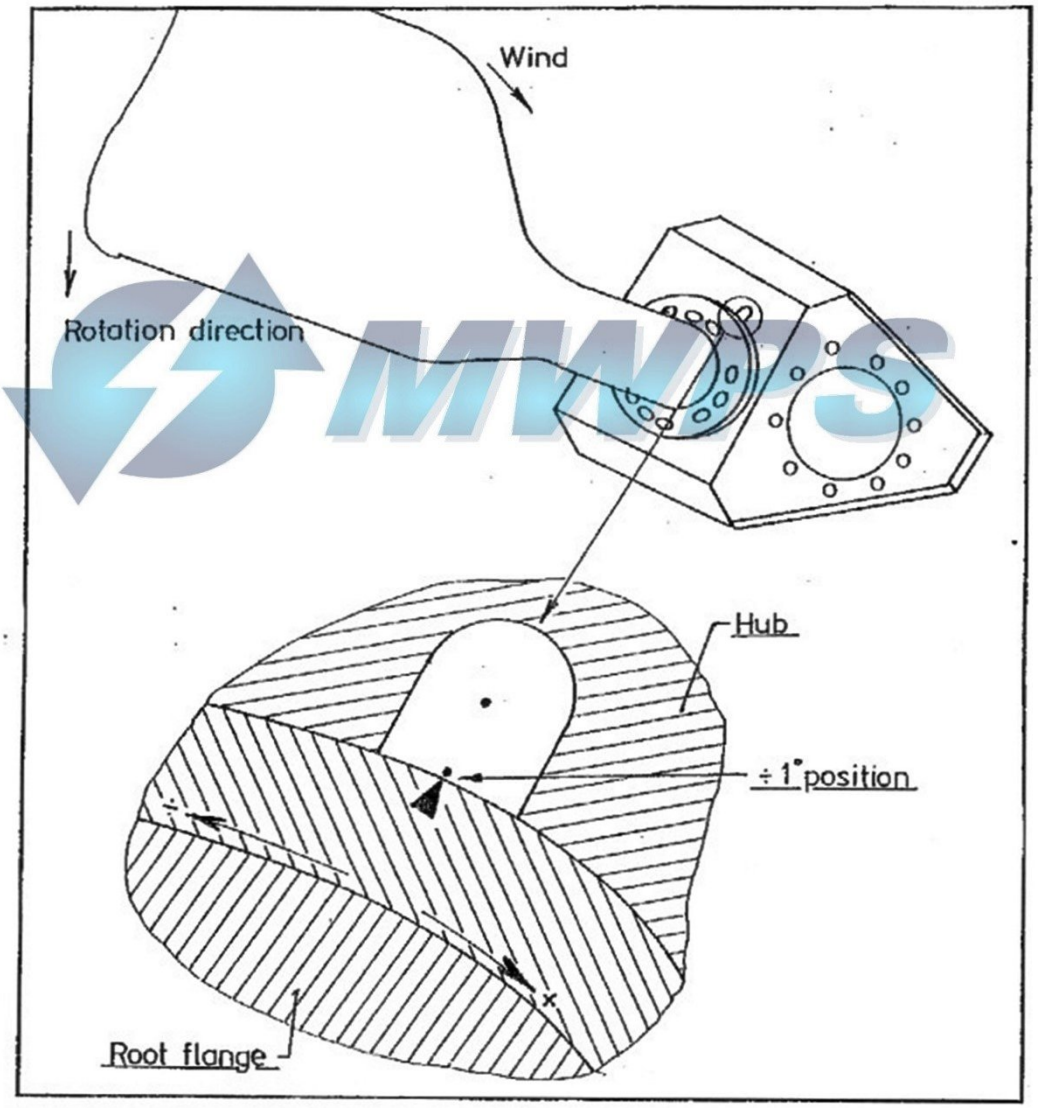
A/S reg. nr. 65 80 03

Vestas

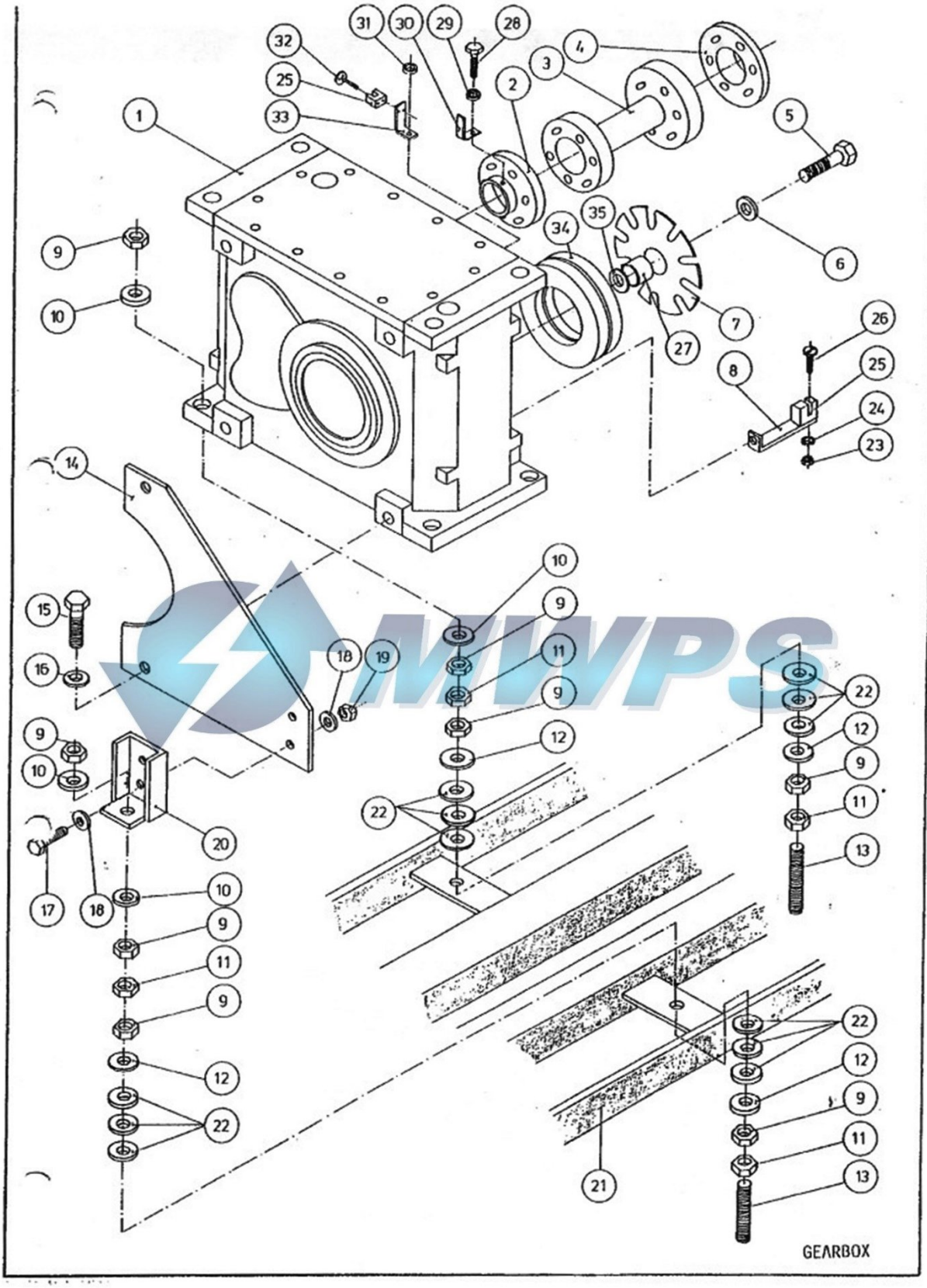
Mounting of blades

The two marks on the hub is placed so when the mark on the blade-root flange is opposite the two marks on the hub, it corresponds to that the tip angle is - 1^{o}.

1^{o} = 4,19 mm on the root flange.



Adresse:	Telefon:	Telex:	Telefax:	Postgiro:	Bank	A/S reg. nr.
VESTAS ENERGY A/S POSTBOX 42 DK 6940 LEM DENMARK	+ 45 - 7 - 341188	60733 VESTAS DK	+ 45 - 7 - 341484	1588508	A/S RINGKØBING BANK 7650-200716-4 DEN DANSKE BANK 3403-14700-1	65003


GEARBOX

VESTAS ENERGY A/S

GEAR BOX V 17-90

POS NR	EDB NR	ENG	ANTAL
1	115185	GEAR 90KW SZ320 FLENDER 1:24.07	1
2	104272	COUPLING FLANGE Ø60	1
3	104264	COUPLING ELEMENT CF-A-140-G 625	1
4	104280	COUPLING FLANGE Ø70	1
5	153909	STEEL SETSCREW M30x 70 FZB 8:8	1
6	155683	FACET WASHER M30 FZB	1
7	867392	SCANNER DISC FZB	1
8	867330	HOLDER FOR SENSOR, GEAR FLENDER	1
9	157198	HEXAGON NUT M24 GALV. 8	8
10	897442	WASHER Ø25 xØ47x8	4
11	157295	COUNTER NUT M24 FZB	4
12	867284	RECESS-WASHER 19/9MM Ø25MM	4
13	867039	THREAD-PIECE QUICK TIE BAR	2
14	866598	PLATE, QUICK TIE BAR	1
15	153907	STEEL SETSCREW M30x 60 FZB	2
16	867276	RECESS-WASHER 19/9MM Ø30	2
17	153745	STEEL SETSCREW M20x 60 FZB 8:8	2
18	897469	WASHER Ø20.5 xØ47x8 FZB	4
19	157619	LOCK NUT M20	2
20	862533	HOLDER, QUICK TIE BAR V17-US	1
21	861553	MASHINE FOUNDATION, READY FOR MOUNTING	1
22	107794	PLATE SPRING Ø80.00xØ36.00x3.00	12
23	157732	LOCK NUT M 4 FZB	2
24	154660	BEVELED WASHER Ø4 MM FZB	2
25	114260	FORK SCANNER DU10 (1425) 3M	2
26	158968	MACHINE SCREW CHJ M 4x 25 FZB	2
27	867306	PIPE FOR SCANNER	1
28	154164	STEEL SETSCREW M16x 20 FZB 8:8	1
29	156817	BEVELED WASHER Ø17.00xØ30.00x3.00	1
30	867373	SCANNER, AT THE BIG GENERATOR	1
31	156639	BEVELED WASHER Ø25.00xØ44.00x4.00	1
32	158844	MACHINE SCREW CHJ M 4x 16 FZB	2
33	867330	HOLDER FOR SENSOR, GEAR FLENDER	1
34	104418	SHRINK DISC 185-71	1
35	155683	FACET WASHER M30 FZB	1

ikrevet = 35