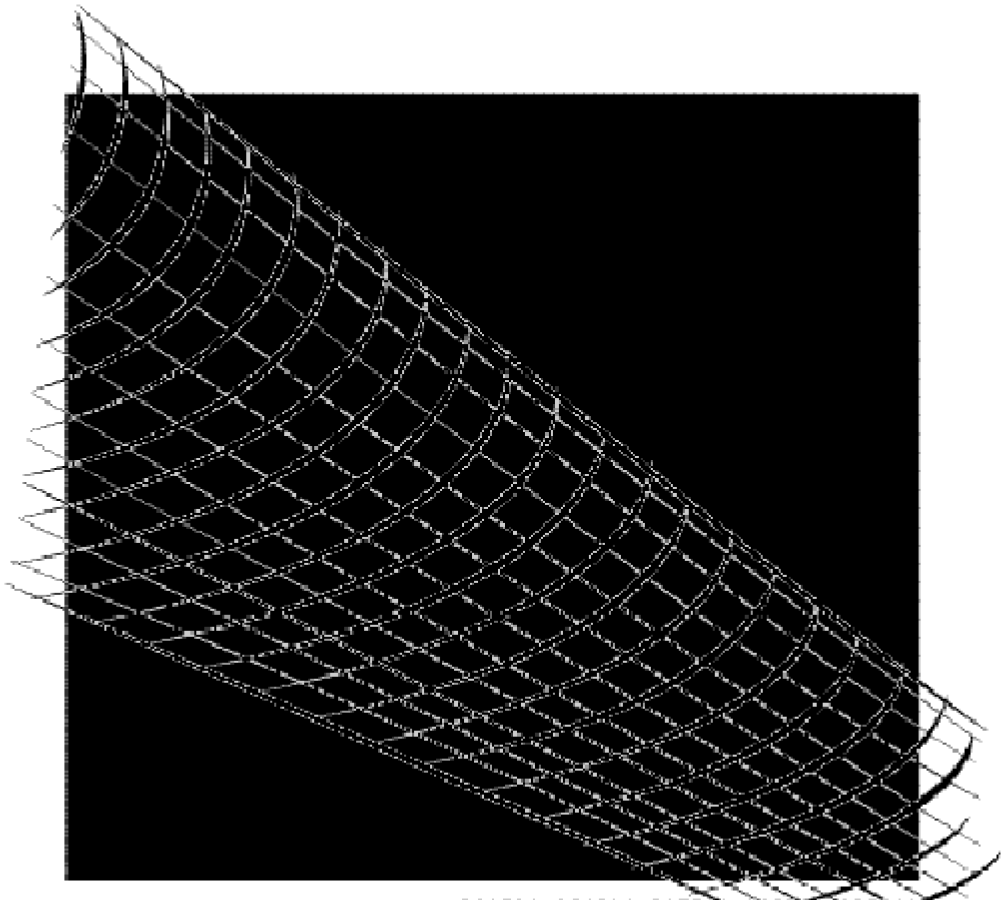
LM 37.3 P2 Technical Manual



Item no.: 072000

CONTACT LM WIND POWER A/S AT THE FOLLOWING ADDRESSES WORLDWIDE:

Headquarters:
LM Wind Power A/S
Jupitervej 6 — Tel.: +45 7984 0000
DK-6000 Kolding — Fax: +45 7984 0001
Denmark — E-mail: info@lmwindpower.com

- Sales — Fax: +45 7984 0002
- Development — Fax: +45 7984 0006
- Service — Fax: +45 7984 0080
- Requisitions — Fax: +45 7984 0020

Global Business Office:
LM Wind Power
WTC, H8 — Tel.: +31 20 30 43 700
Schipol Boulevard 357 — E-mail: lm@lmwindpower.com
1118 BJ Schipol Airport

The Netherlands

Offices:

LM Wind Power Northern Europe
LM Wind Power
Østre Allé — Tel.: +45 79 84 00 00
6640 Lunderskov — Fax: +45 79 84 00 01
Denmark — E-mail: info@lmwindpower.com

LM Wind Power R&D Pvt,. Ltd.
RMZ Infinity — Tel.: +91 80 6647 0200
Tower-B, III Floor — E-mail: info.in@lmwindower.com
Old Madras Road
Benniganahalli
Bangalore – 560 016
India

LM Wind Power Poland Sp. Z.o.o.
Ul. Nowa 3, Łozienica — Tel.: +48 91 46 997 00
72-100 Goleniów — Fax: +48 91 46 997 88
Poland — E-mail: lm-poland@lmwindpower.com

LM Wind Power Co., Ltd.
Quanwang road — Tel.: +86 22 8212 1000
Wuqing Dev. Area, Tianjin — Fax: +86 22 8212 3000
P.R.C. 301700 — E-mail: info@lmwindpower.com

China

LM Wind Power Holland B.V.
J. Duikerweg 15A — Tel.: +31 725 76 70 70
P.O Box 1126 — Fax: +31 725 74 22 12
1703 BC Heerhugowaard — E-mail: info.nl@lmwindpower.com
The Netherlands

LM Wind Power Co. Ltd.
No. 501, Lu Shan road
Eco. & Tech. Dev. Zone
Urumqi, Xinjiang
P.R.C. 83001
China

LM Wind Power Deutschland GmbH
Industriestr. 5 — Tel.: +49 039 225 63 09 0
D-39291 Schopsdorf — Fax: +49 039 225 63 09 10
Germany — E-mail: info@lmwindpower.com

LM Wind Power Southern Europe
LM Wind Power Española, S.A.
c/ Anabel Segura no. 11 — Tel.: +34 91 490 72 00
Centro de Negocios Albatros — Fax: +34 91 490 72 01
Edificio A, 2a planta, Dpt. B
28108 Alcobendas — E-mail: info@lmwindpower.com
Spain

LM Wind Power North America
LM Wind Power (AR), Inc.
8000 Frazier Pike — Tel.: +1 501 801 6300
Little Rock — Fax: +1 501 801 6789
Arkansas 72206 — E-mail: info@lmwindpower.com
USA

Further information may be obtained from our web site: www.lmwindpower.com

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Figure and table list

Figure no. and description

Table no. and description

1 INTRODUCTION

1.1 PREFACE

This technical manual is aimed at the professional operator/user of LM Wind Power blades and it contains information about blade structure, build-up, mounting, maintenance and conditions of use.

This manual is based on up-to-date information and data. Thus, this manual is only instructive in connection with blade mounting, adjustment, maintenance and repair.

This technical manual should be thoroughly read prior to blade mounting, installation, maintenance or repair.

This manual does not include wind turbine data or work performed at or on the wind turbine. If you have any questions, please do not hesitate to contact the Service Department at LM Wind Power.

1.2 MANUFACTURING DECLARATION

LM Wind Power hereby confirms that the LM 37.3 P2 blade **(item no. 072000)** is certified according to ”Richtlinien für die Zertifizierung von Windenergieanlagen – Germanischer Lloyd, 2003“.

The wind turbine supplied with this particular blade should not be put into operation unless a similar declaration has been issued for the wind turbine stating that it complies with ”Richtlinien für die Zertifizierung von Windenergieanlagen – Germanischer Lloyd, 2003“.

1.3 SAFETY REQUIREMENTS

All blade-related work, i.e. mounting, installation, adjustment, maintenance, service, repair and cleaning, should comply with ordinary safety requirements as well as safety requirements stated by LM Wind Power.

LM Wind Power is not liable for defects deriving from any non-compliance with the safety requirements mentioned in this technical manual or any other prevailing safety requirements.

1.4 TECHNICAL MANUAL

In this manual the following symbols are used:

Important information

Very important information requiring special attention!

CAUTION! Note the warning sign that warns about a potential danger or cause of damage! Be alert and comply with the requirements specified!

This manual specifies important requirements for safe and correct blade application. Compliance with the requirements specified reduces the risk of injury, additional blade costs or blade defects significantly.

Any person working in the vicinity of the blade manufacture should be familiar with the information stated in this technical manual.

The owner of the wind turbine on which this particular blade is mounted is responsible for educating and training employees as to carry out blade mounting, adjustment, service and maintenance according to the contents of this technical manual.

This technical manual is to be positioned inside the wind turbine.

1.5 TECHNICAL BLADE TERMS

Pitch angle............................The angle between rotor plane and tip chord. A positive pitch angle is achieved when the blade trailing edge is facing the tower, whereas a negative pitch angle is when the blade trailing edge is facing the wind.

Tip chord...............................The chord of the reference profile. Determination of the reference profile depends on constructive considerations in connection with the blade design.

Chord....................................The profile length measured between leading and trailing edges.

0° marking ....Marking of the tip chord. 0° marking is placed on the blade root as well as externally and internally on the root flange (see figure 3).

Alpha measurement ....Seen from the blade tip end, it is the angle between the reference tip chord and first bushing hole in the clockwise direction. This measurement is used in connection with the design of the blade-hub connection.

Centre of gravity....................The centre around which the blade is balanced. The centre of gravity is marked as it is decisive in connection with blade handling and transportation.

Upwind side ....Pressure side, i.e. the blade side facing the wind.

Downwind side......................Suction side, i.e. the blade side facing away from the wind. Due to the aerodynamic profile shape, this side generates the lifting power.

Pre-bending ....The blade is pre-bent against the wind to prevent it from deforming towards the tower during operation.

Lightning conductor system....System that captures and conducts lightning strokes.

Receptor ....Metallic devices mounted into the blade surface in order to conduct a lightning stroke away from the blade and avoid damage.

Blade twist ....The blade twist at any blade profile sectional view.

1.6 PRODUCT: WIND TURBINE BLADE

The wind turbine blade has been designed solely for application on a rotor hub suitable for 3 blades[1]. Any other blade application is not allowed, and LM Wind Power cannot be held liable for any injury or damage caused by inappropriate blade application.

The blade has been manufactured using up-to-date techniques in order to comply with well-known and recognised technical guidelines and standards. However, blade application implies certain risks and dangers. Thus, the wind turbine blade should only be operated technically correct within its field of operation, i.e. in accordance with the technical requirements specified in this technical manual.

Defects negatively influencing the blade safety should be repaired immediately.

Changing or reconstructing the wind turbine blade is prohibited without prior written approval from LM Wind Power.

1) The wind turbine blade application should solely comply with EN 292-1 (Safety of machinery, 1991) in order to guarantee a correct wind turbine operation.

According to this standard, blade application should comply with regulations, technical data and descriptions - as well as the sales brochure - prescribed by LM Wind Power.

Correct application also includes compliance with this technical manual.

All blade declarations, instructions and markings should remain visible throughout the entire blade service life.

1.7 HUMAN RESOURCES

All work should be performed by qualified and trained employees in compliance with this technical manual. Any other person working on the blade is supervised by a qualified colleague.

The warranty becomes void if blade-related work is performed by unqualified and untrained persons.

1.8 SERVICE, MAINTENANCE AND REPAIR

Servicing intervals

The warranty may become void if regular service inspections are not performed as prescribed in this manual.

Tools

Only intact and up-to-date tools should be used for maintenance and repair.

Tools should always be applied correctly according to their instructions for use.

Only metric tools should be used.

Lifting gear

Only approved and technically correct lifting gear without any defects should be applied. Check that the lifting gear has a sufficient load-carrying capacity (see chapter 3).

Only qualified persons may fasten the load and give instructions to the operator of the lifting gear. The qualified person should be visible to the operator of the lifting gear. Alternatively, a radio contact can be established in the event that visual contact is impossible.

CAUTION! Note that work should not be performed underneath a lifted load.

Work above head height

A safe and approved ladder and catwalk should be applied.

CAUTION! Note that any large-sized height requires the application of a cage-arresting device!

Cleaning

After a while and depending on the surrounding environment, a layer of insects and dirt may appear on the wind turbine blade in operation – in particular on the blade leading edge. Such a layer badly influences the blade effectiveness. Thus, a regular blade cleaning is recommended by LM Wind Power.

Various car and boat cleaning agents can be applied for gel coat surface cleaning and maintenance.

Do not use metal brushes or aggressive cleaning agents for blade cleaning.

Check the blade after cleaning. Any defects should be repaired immediately.

1.9 RESIDUAL PRODUCTS AND ENVIRONMENTAL PROTECTION

Environmental Protection

Check that residual products, i.e. oil, grease, epoxy, polyester, peroxide and solvents, are removed environmentally correct. This also applies to residual hydraulic oil, residual grease as well as other residual chemicals. All waste should be removed in approved packaging or original packaging.

PE plastic film (packaging) should be assorted and recycled, if possible. Separate handling of residual polyester, residual organic solvents as well as other chemicals is required.

Glass fibre-reinforced polyester is subject to incineration in an incineration plant or should be dumped at a waste disposal site depending on local conditions and regulations.

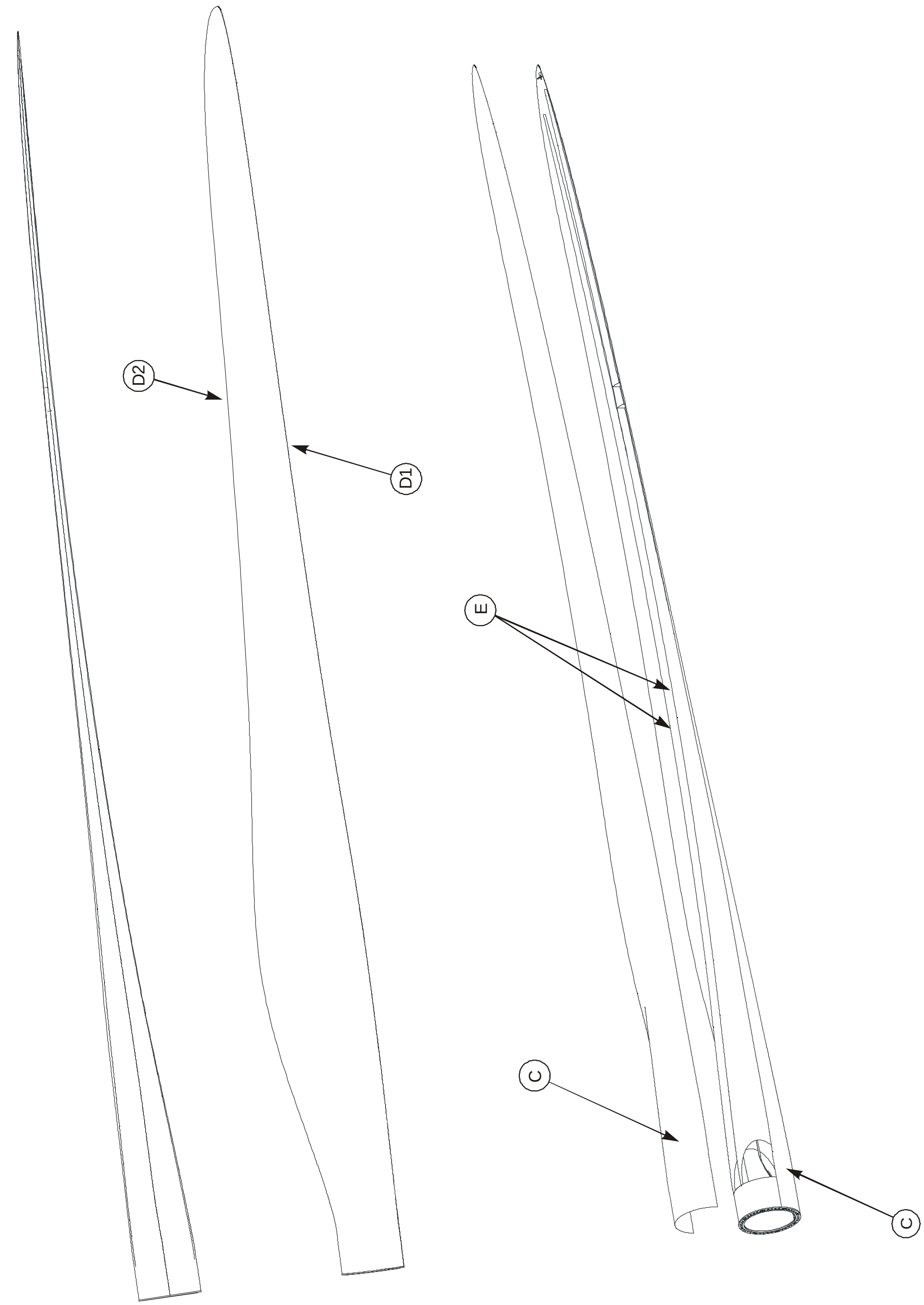

Figure 1 Main blade components

2 GENERAL DESCRIPTION

Construction

LM blades consist of 2 blade shells (see (C) in figure 1) that are bonded together in leading edge (D1) and trailing edge (D2) and along the two centrally positioned main webs (E). The main web function is to keep a distance between blade shells and transfer transverse shearing forces from the wind load.

Blade shells

Blade shells (C) forming the aerodynamic shape of the completed blade consist of base laminate made of ± 45° fibres (according to the longitudinal blade direction) and sandwich panels, i.e. laminate with centred foam or balsa. The sandwich panel function should increase the blade shell bending stiffness, thus preventing instability during compressive loads also referred to as buckling.

Main laminate carrying large-sized aerodynamic forces is made of unidirectional fibres (0°) resulting in optimal stiffness and low-levelled materials consumption.

The proper blade weight towards leading and trailing edges are carried by blade shells and by the reinforced laminate positioned along leading and trailing edges. Reinforced laminate is also made of unidirectional fibres (0°).

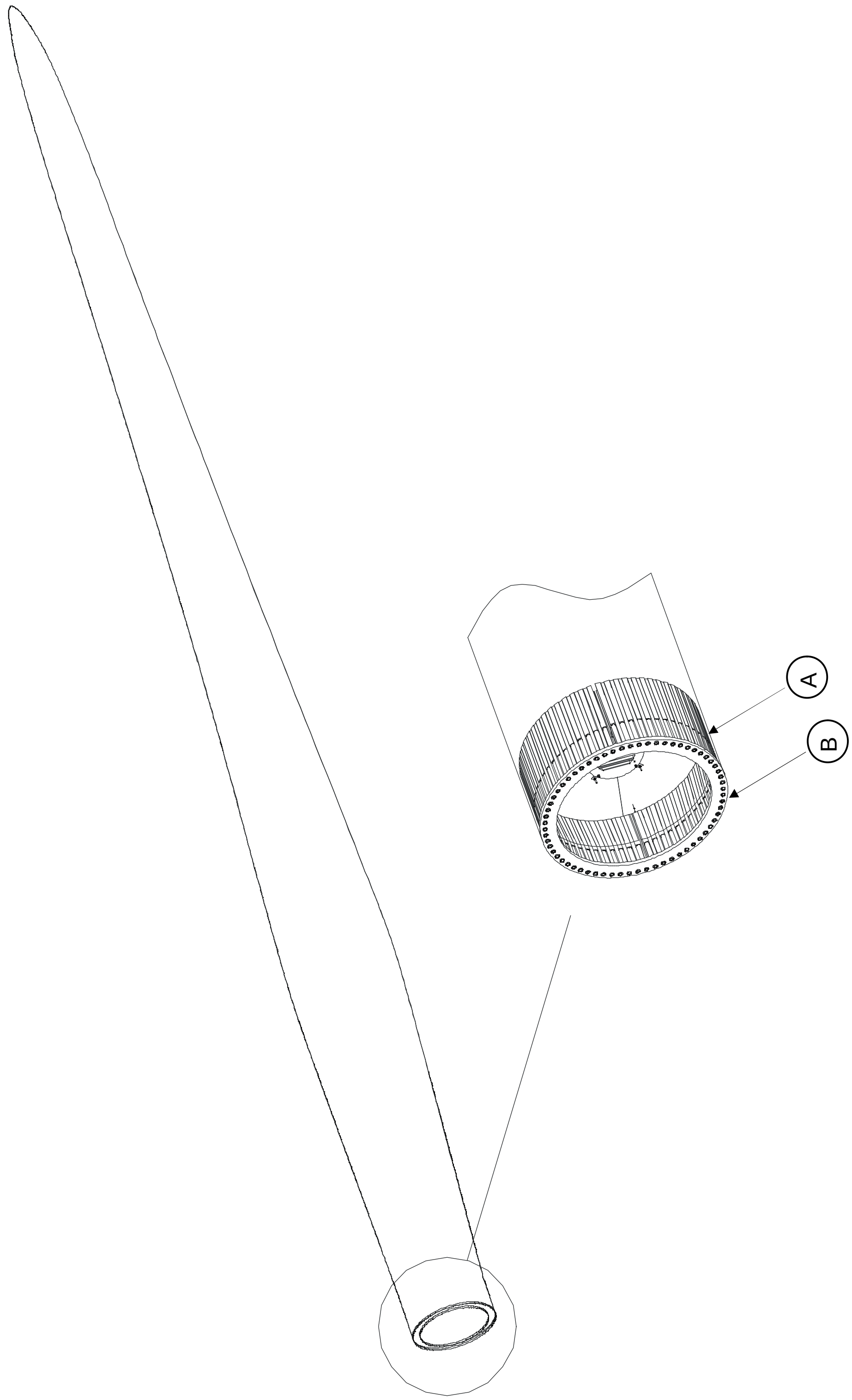

Figure 2 Blade root end

Blade mounting

Blades are mounted on the wind turbine hub by means of embedded bushings (See (A) in figure 2) in the blade root laminate. Bushings are made of a chromium steel alloy having an internal thread. A high-quality screw-bolt connection is the result of the thread being positioned at a given distance from the bushing contact face (see bushing size in the table in figure 5). Between bushings and wind turbine hub, the root flange (B) (a galvanised steel flange or a stainless steel segment flange) should end the blade and prevent water from entering into the blade.

Blade surface

The blade surface consists of weather and UV-resistant gel coat having a customer-required colour. The gel coat protects the laminate against air humidity and wear and tear.

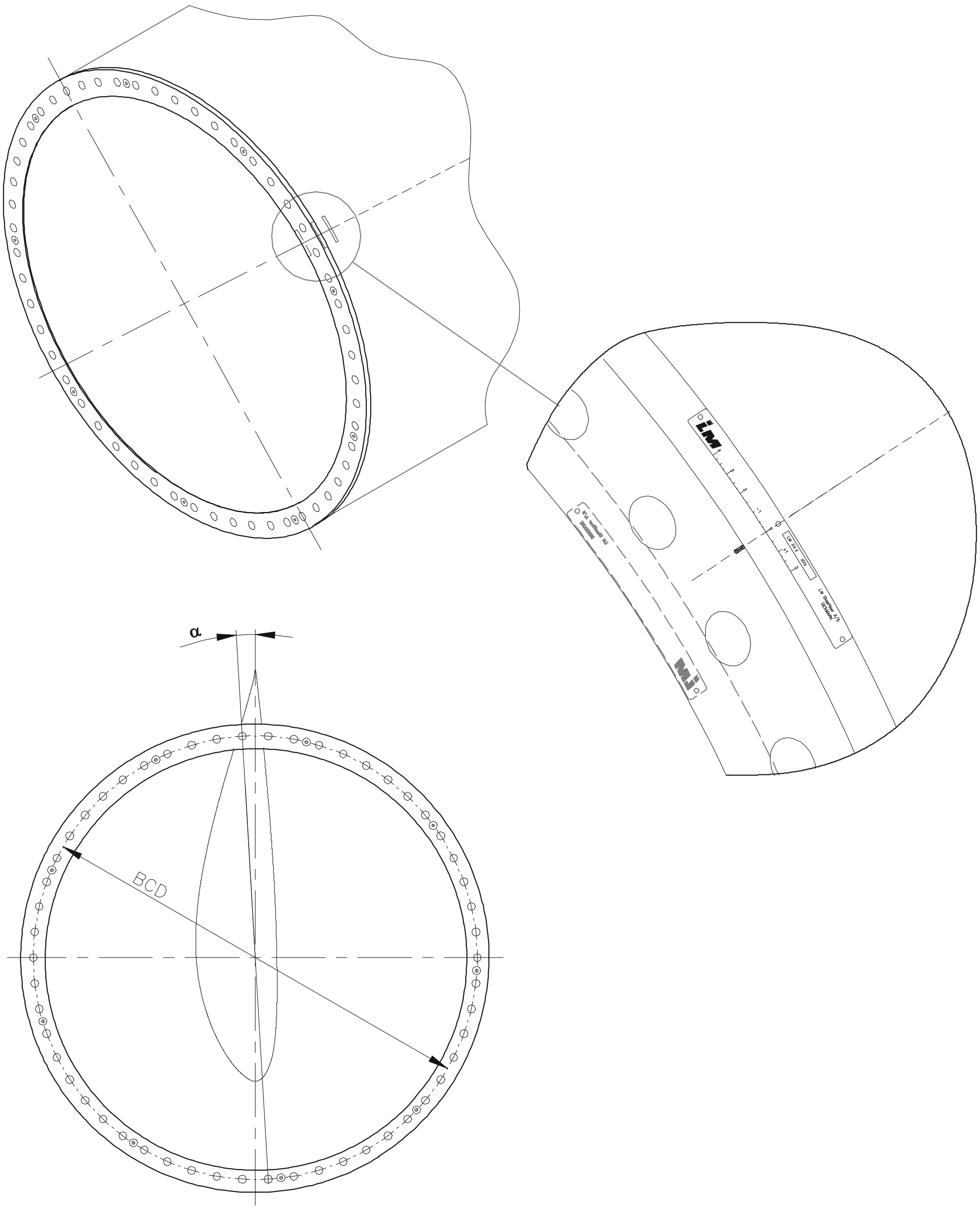

Figure 3 0° marking and alpha measurement on blade root end

Blade profile series

Blade profile series chosen have been thoroughly tested and validated, and they are a result of many years of experience from previous wind turbine blades manufactured. Blade profile series chosen utilise the wind energy, and they are only to a minor extent affected by impurities appearing on the leading edge profile.

ISO 9001

The blade manufacture at LM Wind Power is performed in accordance with DS/EN ISO 9001.

In connection with the manufacture monitoring, a “product certificate of conformity” can be issued by Germanischer Lloyd or Det Norske Veritas.

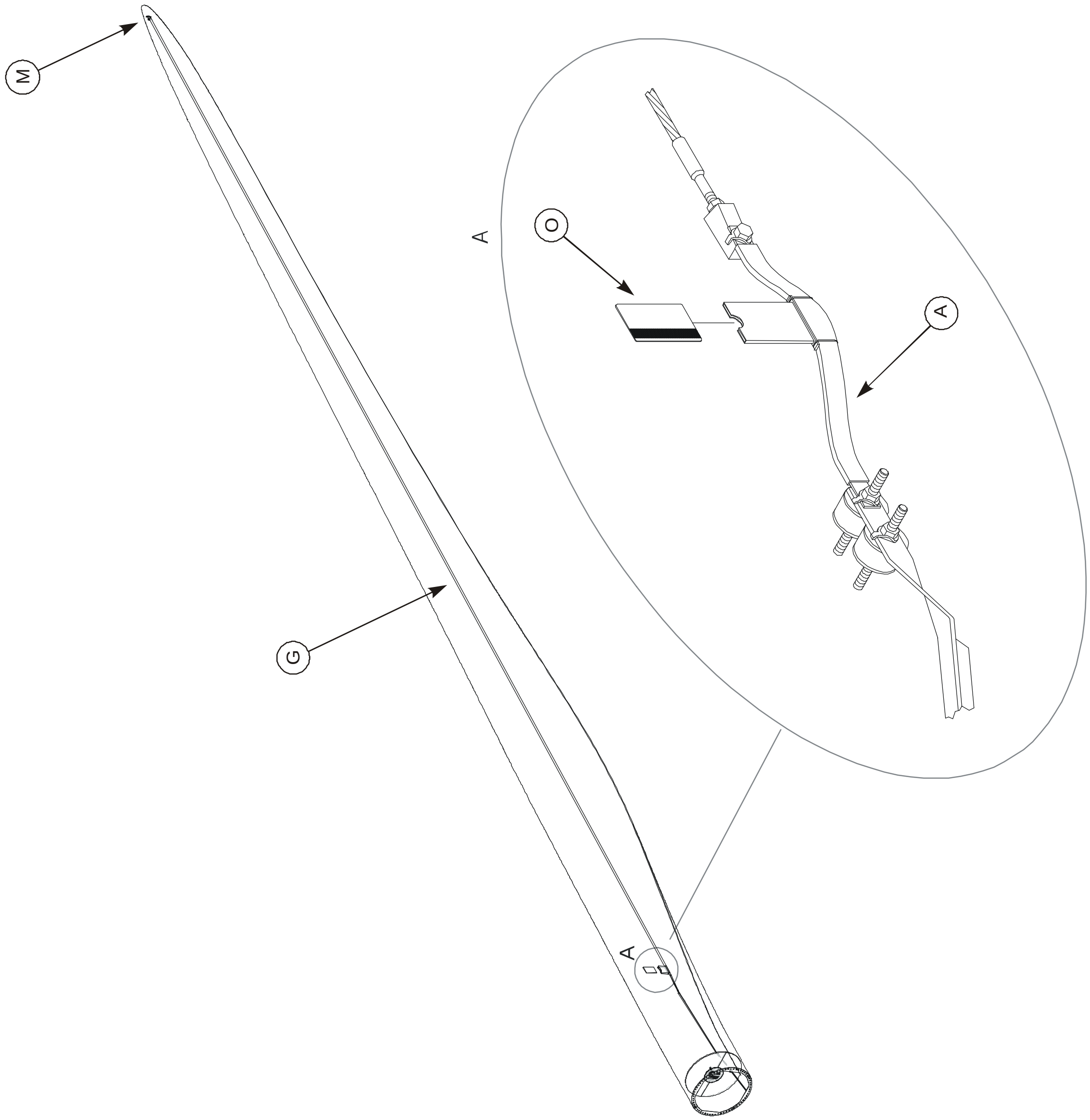

Figure 4 Lightning conductor system

2.1 LIGHTNING CONDUCTOR SYSTEM

Lightning system

The lightning conductor system (see G and figure 4) consists of lightning receptors integrated in the blade surface and one drain receptor at the tip (M). Lightning receptors and drain receptor (M) are connected to the root flange by means of built-in lightning conductor component parts. Replacement of lightning receptors and drain receptor (M) is described in the section “Service and maintenance”.

The lightning conductor system is constructed to ease maintenance requirements, as lightning receptors and drain receptor (M) are the only component parts requiring maintenance.

Two lightning receptors are placed close to the tip end at each side of the blade. A third one is located at the very tip end and is equipped with a drain hole to combine the drainage together with catching the lightning strokes.

If the use of a drainage receptor isn`t desired, 3 new holes in the trailing DW tip edge shall be drilled together and/or a diverter going from the DW tip receptor towards the three new drainage holes is mounted.
In that case are drain holes and/or diverter component parts requiring maintenance.

The lightning conductor system (G) corresponds with the IEC standard 61312-1 level 1 “Simulation of the lightning current for test purposes” according to which all main component parts have been subject to laboratory tests simulating the effect and behaviour of the system when exposed to a lightning stroke. In addition, field tests on blades struck by lightning reveal the capability of the system to conduct lightning currents.

Lightning registration

Furthermore, the blade is equipped with a lightning registration card (O) mounted on the blade root transition piece (A). The purpose of the lightning registration card is to record any lightning currents appearing in the lightning conductor system. Thus, further service inspections may be considered necessary in order to detect any defects or damage on the wind turbine.

When the lightning receptor is struck by a lightning stroke, magnetic stripe data on the lightning registration card is deleted. Thus, the lightning current of the large-sized lightning stroke is always recorded on the lightning registration card.

The lightning registration card dimensions enable maximum measurement readings up to 400 kA on the low coercive tape (light brown) and between 50 to 800 kA on the high coercive tape (dark brown). Replacement and reading of the lightning registration card are described in the section “Service and maintenance”.

Continuous research activities including laboratory tests and on-site experience ensure that LM Wind Power always applies up-to-date technology.

Table 1 Blade design parameters

Blade length (excl. root flange)	1	37300 mm	± 37 mm
Max. root chord	C_{root}	3097mm	± 20 mm
Blade area	A	70 m² 160 m²	Projected Wetted
Blade twist at max. chord		14.0 °	± 0.5 °
Profiles		Wortmann FX 77/79 Mod. NACA 634	
Natural frequency, flapwise		0.94 Hz	Measured on prototype
Natural frequency, edgewise		1.75 Hz	Measured on prototype
Blade mass incl. root flange, excl. stay bolts	m	5590 kg	± 3.0 %
Centre of gravity distance from root flange	C.o.G.	11380 mm	
Moment caused by gravity at blade root		624 kNm	± 4.5%
Direction of rotation (from upwind side)		Clockwise	
Self-starting		Yes	

3 TECHNICAL SPECIFICATIONS

3.1 DESIGN PARAMETERS

The blade design parameters are shown in Table 1.

The blades in one rotor set are balanced to have a similar moment caused by gravity. Thus, blades are balanced around the rotor centre both dynamically and statically to match the diameter according to which they were weighed. Blades should only be used for the rotor diameter stated in the blade certificate. Balancing data is recorded at LM Wind Power in the event that a replacement is necessary.

Table 2 Installation parameters

Outer root flange diameter	D_{outer}	1895 mm	+1/-0mm
Root flange thickness, galvanised. Optional is a thinner stainless steel segment flange.	W_F	Optional	Optional
Bolt circular diameter	BCD	1800 mm	± 1 mm
Number of bolts	n	54	
Bolt size	M	30 mm	
Alpha measurement Seen from root end. The angle between the reference chord (21.7 m from root) and first bushing hole in the counter clockwise direction.		3.3°	± 0.5°
Tracking tolerance (Difference in distance from the tip to tower between the three blades)			±370 mm from nominal
Recommended minimum distance between blade tip and tower in unloaded condition (see valid load calculations)		Specified in acc. with the customer	

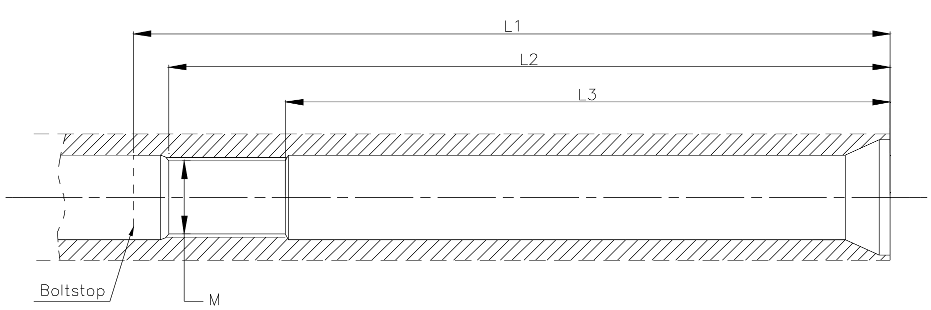

Figure 5 Principle drawing of embedded bushing

Bushing size	L1	L2	L3	Thread
M30	289	278	229	30x3.5

All measurements are stated in “mm”.

3.2 INSTALLATION DIMENSIONS

The installation parameters for the blade are shown in Table 2.

3.3 GFP / STEEL CONNECTION

Embedded bushings of high-strength steel with internal thread (see figure 5).

3.4 AERODYNAMIC BRAKE

Type	Pitch-regulated

Table 3 Materials used in blade

Blade shells, webs, root section	Glass fibre-reinforced polyester
Sandwich core	Balsa wood (blade shells and webs) PVC foam (ribs and platform)
Adhesive	Vinylester
Embedded bushings	Chromium steel alloy
Root flange	Galvanised steel or stainless steel
Lightning receptors	Highly alloyed material resistant to high temperatures
Lightning conductor cable	Tinned copper/stainless steel

Table 4 Rotor configuration

Number of rotor blades	3
Rotor positioning	Upwind / in front of the tower
Power control	Pitch-regulated
Yaw system	Forced
Hub design	Stiff

Table 5 Design limits for blade operation

Rotor diameter	D	77 m	
Tip speed	V_{tip}	74 m/s	
Generator power	P_{el}	1500 kW	[1]
Yaw error (oblique load during operation)	sw	10°	[2]
Cut-out wind	V_o	25 m/s	[1]
Brake moment (emergency)	$M_{br,e}$	TBD kNm	

[1] A 10-minute average value. Wind speed stated at hub height.

[2] At a max. yaw error (oblique load) of 10°, the angle between the wind direction and rotor shaft has a systematic average value of 10° and a standard deviation of 10°.

Table 6 Meteorological conditions

Operation temperature	Min. –30°C – Max. 55°C OAT (Outside Ambient Temperature).
Icing	***Under extreme external conditions resulting in an iced up rotor imbalance, a wind turbine standstill is required until de-icing has taken place.***
Meteorological conditions	According to IEC wind class IIA.

LM Wind Power reserves the right to change the specifications without prior approval.

3.5 MATERIALS USED

The materials used in the blade are shown in table 3.

3.6 ROTOR CONFIGURATION

The parameters for the rotor configuration are shown in table 4.

3.7 DESIGN LIMITS

The blade is designed according to wind class IEC IIA.

Operational limits and load limits of the blade are included in the load calculations prepared for the specific wind turbine equipped with the blade in question. The wind turbine manufacturer is responsible for taking the necessary measures to ensure that the load calculations prepared include load limits and extreme strain and fatigue limits that should not be exceeded at any time.

The design limits for the blade operation are shown in Table 5.

3.8 METEOROLOGICAL CONDITIONS

The allowable meteorological conditions for blade operation are shown in Table 6.

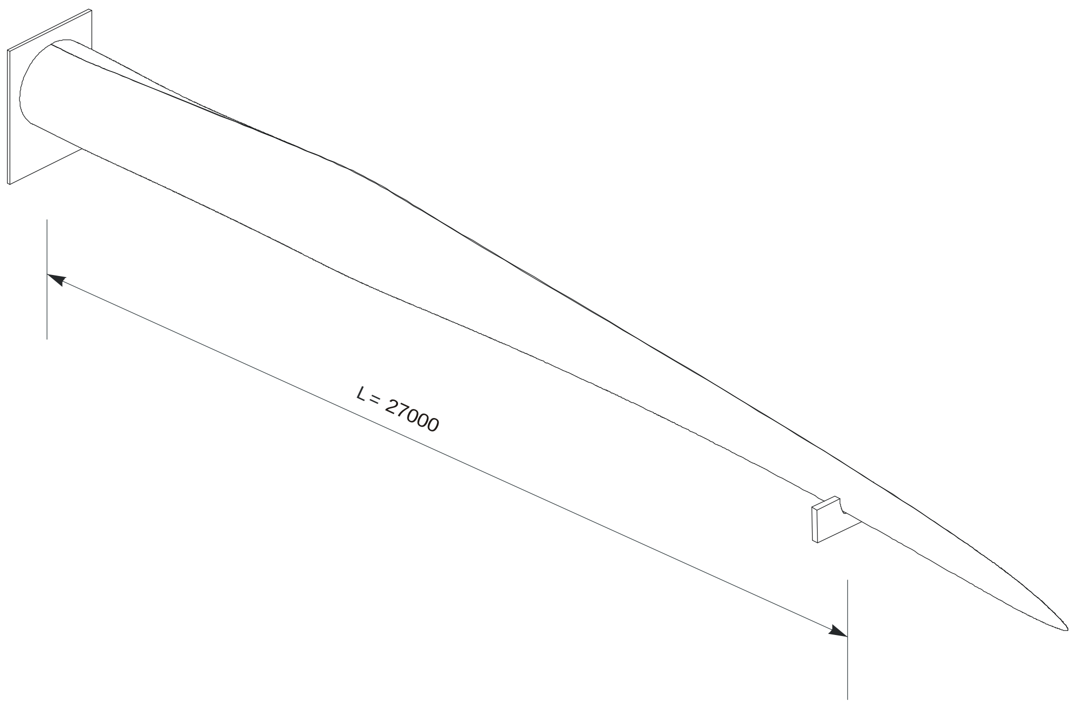

Figure 6 Long-term blade storage.

The blade is fastened on to a rack in the root end, whereas the tip is positioned in a designed rack.

4 BLADE HANDLING

4.1 GENERAL SAFETY REQUIREMENTS

Blade handling should be performed with caution! The blade should not be damaged during lifting and handling. Transportation defects should be repaired immediately. In case of doubt, do not hesitate to contact the LM Service Department.

CAUTION! Note that the lifting gear should be certified. The blade tip should always be guided during handling and/or lifting. If necessary, use a rope and remember to remove the rope from the ground after having completed the assembly.

The blade length results in high moment of inertia acting on the rotating blade. This makes the blade handling difficult. Thus, blade handling should be performed with caution. Avoid quick movements and observe the entire blade during handling.

CAUTION! Never underestimate the wind speed!

Remember that blades are aerodynamically designed. Wind turbine blades have a large surface area compared to their proper weight, i.e. the blade has a considerable angle of attack. Even low wind speeds may have a considerable impact on the blade. Make sure that employees holding the blade are firmly and safely positioned. If necessary, a rope should be fixed by means of high-strength stabile points.

4.2 STORAGE

The blade should always be stored freely, i.e. the blade is not allowed to touch the ground.

Strictly observe and perform handling according to LM handling, transport and storage instructions.

Blade lifting and handling are described in the blade handling instruction attached to the blade surface at the root end.

At long-term storage, the blade should be protected from ultraviolet rays to avoid colour deviations.

The blade should be positioned in suitable racks with soft supports between the blade and rack (see Figure 6).
At edgewise storage, make sure that the leading edge of the blade does not touch the ground.

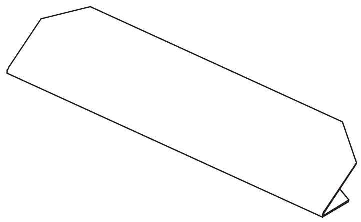

Figure 7 Steel trailing edge protection device for blades.

Length = approx. 1000 mm, height = 250 mm, sheet thickness = 4 mm.

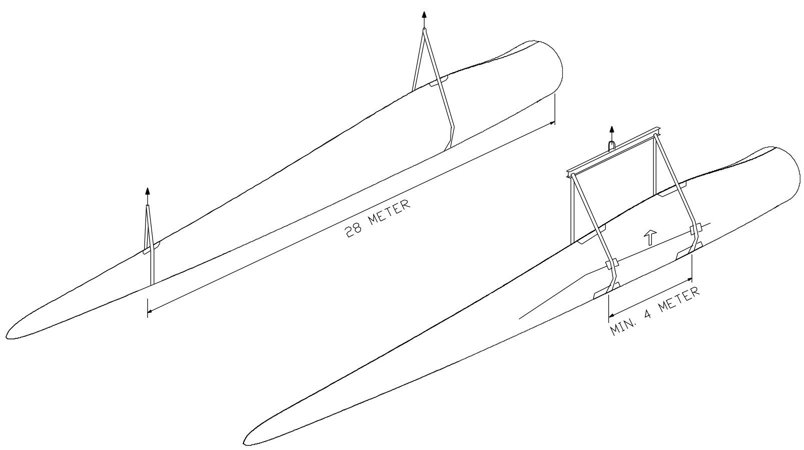

Figure 8 Blade lifting (only vertical)

Do not forget the trailing edge and Vortex panel protection. Trailing edge should always be lifted upwards.

4.3 BLADE TRANSPORTATION

***Blade transportation requires special equipment*.**

1. The blade is positioned in a root fixture fastened by means of bolts. In tip end, the blade rests on a transport cradle that is covered with a soft material protecting the blade. A strap supports the blade.

2. **Prior to blade unloading (see figure 8), it should be ensured that the following lifting gear is available on site:**

   - Trailing edge protection (see figure 7) is applied on the blade trailing edge where lifting straps should be applied.

   - Lifting straps min. 120 mm wide.

3. Trailing edge protection is applied on the trailing edge where lifting straps touch the trailing edge.

   Vortex-panel protection must be applied.

4. Depending on the working conditions, the blade can be lifted in 2 ways (see figure 8). If the method shown in the right-lower part of figure 8 is used, the blade is lifted by means of lifting straps applied symmetrically around the blade centre of gravity.

   The centre of gravity is marked by means of a centre of gravity sticker on the blade. Place lifting straps at suitable intervals, thus the blade can be handled carefully during lifting.

Note that vertical blade lifting should always be performed with the trailing edge facing upwards!

5. Blade lifting and handling are described in blade handling instructions attached to the blade on the external blade side near root end.

6. **The following is checked after having unloaded the blades:**

   - wear and tear as well as buckles from the tip end fixture,

   - any cracks and markings in leading and trailing edges,

   - blade surface condition.

7. If the blade is stored on the ground, it is applied with a root fitting and supported using a tip end fixture. The blade is stored in an upright/edgewise position (see figure 6).

5 BLADE MOUNTING

5.1 BLADE NUMBERS

Prior to blade mounting, the blade numbers are written down. Blade numbers are embedded in the side surface of the flange (see figure 3). The blade number for each blade is visible in the following locations:

1. Externally, plastic signs glued on the surface
    a. At the root end, downwind and upwind side
2. Internally, a metal sign
    a. Located close to the 0° mark, close to the leading and trailing edge of the blade

It should be noted that the external signs will be exposed to the elements and can be expected to fall off after some time in service.

5.2 LABEL REMOVAL

Prior to blade mounting remove the handling zone labels (see figure 9) on both upwind and downwind.

5.3 BLADE INSPECTION

The following inspection should be performed to ensure that the blade has not been damaged during transportation:

Surface condition

The gel coat surface should appear clean and smooth without scratches. If this is not the case, the defect should be repaired.

Leading and trailing edges

The leading and trailing edges should be checked for signs of damage.

Damage from transport equipment

The blade should be checked for damage from all transport equipment.

Information is applicable to ISO quality bolts.

The screws should be thoroughly applied with copper grease or the like

Table 7 Extracts from VDI 2230

Bolt	Quality 8.8	Quality 10.9
M20x2.5	90% preload: 134 kN Preload moment:363 Nm	90% preload: 190 kN Preload moment:517 Nm
M24x3	90% preload: 192 kN Preload moment:625 Nm	90% preload: 274 kN Preload moment:890 Nm
M30x3.5	90% preload: 307 kN Preload moment:1246 Nm	90% preload: 437 kN Preload moment:1775 Nm
M36x4	90% preload: 448 kN Preload moment:2164 Nm	90% preload: 638 kN Preload moment:3082 Nm

Hexagon socket headless screw with metric thread according to DIN 13-13, bolts according to DIN EN 24014 or DIN 912, and hole diameter medium according to DIN EN 20273.

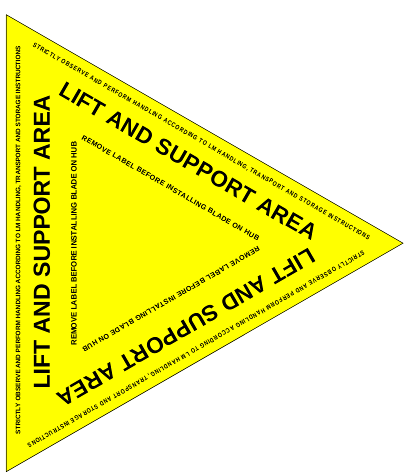

Figure 9 Remove label before installation

5.4 BLADE MOUNTING ON HUB

It should be ensured that the root flange is abutted against the hub. Remove dirt and foreign matters.

The blade should be assembled in the correct position (pitch angle). The blade is adjusted according to the 0° marking of the blade (see figure 3).

Bolt torque procedure and torque values are defined by the turbine manufacturer. These must be strictly followed; otherwise the bolt connection may be unsafe.

Bolts should be re-tightened after approx. 200 hours of operation.

Bolts should be new and they should at least correspond with ISO quality 8.8.

The bolt sliding surfaces should be lubricated with molybdenum sulphide or the like.

Bolts are tightened according to the instructions of the turbine manufacturer, as an example the torque values according VDI 2230 to be applied for <u>non-tapered</u> bolts are listed in Error! Reference source not found..

If the hub is made of cast steel, flat washers of a hard steel quality should be used between bolt head and cast steel.

Blade mounting on wind turbine

Different methods are applied for blade mounting on a wind turbine. Either the entire rotor is mounted or one blade is mounted separately, i.e. one blade at a time.

Different lifting gear is used depending on the method applied. However, it should always be checked whether the lifting capacity of the lifting gear is adequate.

Separate blade mounting

Lifting straps are positioned to prevent the blades from being damaged during mounting. Use lifting straps min. 120 mm wide. The blade weight is stated in blade handling instructions attached to the blade root end.
Lifting straps are positioned in such a way that they can be removed from the ground by means of a rope. However, this should be tested in advance. Furthermore, minimum 2 ropes should be mounted.

The lifting gear and ropes are removed after blade mounting.

5.5 RANGE OF MOTION IN THE ROTARY PLANE

At blade standstill, the full range of motion in a rotary plane is examined in measuring the distance from the blade tip to the tower.

For all 3 blades the measurement is performed at the exact same spot on the tower.

Table 8 Service intervals

Age (months)	Glass fibre (See page 41)	Lightning conductor system (See page 47)	Features (See page 53)
12	+	+	**+**
24		+	**+**
36	+	+	**+**
48		+	**+**
60	+	+	**+**

+ : Service should be performed.

Blank fields: Service is not considered necessary.

Service intervals for wind turbine blades must be performed as in Table 8, and after 60 months the cycle of service intervals must continue in the same pattern.

6 SERVICE AND MAINTENANCE

6.1 SERVICING INTERVALS

Extreme pressures are exerted on a wind turbine blade. Thus, it is decisive that the blades are regularly checked in order to detect and repair any defects at an early stage, so that these small-sized defects do not significantly reduce the blade service life or cause any danger.

Comply with the stated servicing intervals and control points, otherwise the warranty becomes void.

Record all observations made in connection with the regular service inspections performed.

If a lightning stroke occurs in one or several blades, service inspections of lightning receptors and blade surfaces are required.

The required servicing intervals for wind turbine blades are shown in table 8.

6.2 SAFETY

CAUTION! For safety reasons, service should only be performed at a low wind speed. The wind turbine service technician determines when the diurnal conditions allow the service to be performed safely.

The rotor should be stalled and mechanically secured according to prevailing specifications for mechanical locking.

Internal blade inspection should only be performed while the rotor is secured and the blade is positioned horizontally.

The following instructions also apply during servicing:

The lift used should be certified and considered suitable for the job. The lift should be positioned on a firm and solid ground. The lift should never cross the rotor area. Do not fasten the lift basket to wind turbine blades. The lift basket operator should stay inside the basket, while it is lifted.

Do not walk/stand on the hub unless dry weather conditions enable you to do so. Wind turbine service technicians should always be equipped with a safety cable being properly fastened to the wind turbine. Wind turbine service technicians should wear safety shoes, helmet and suitable clothing.

Keep a safe distance away from blades being serviced.

Do not enter into or stay inside blades during a thunderstorm, as this is considered dangerous.

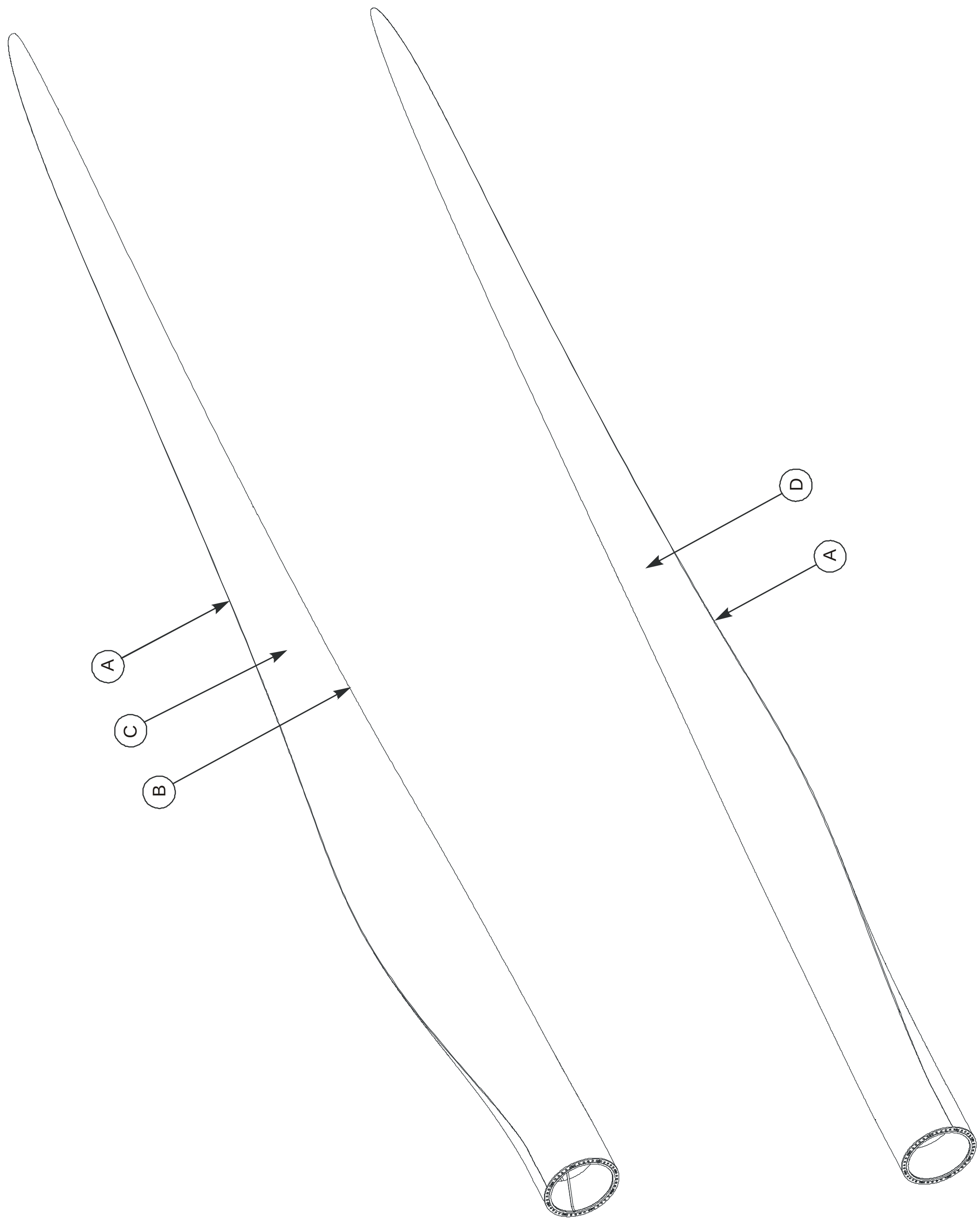

Figure 10   Maintenance of glass fibre component parts

6.3 LAMINATE

Initially, glass fibre component parts of the blade shall be checked after 12 months of operation and then again every 24 months (see Table 8).

As to optimise business economics and reliability of operation, the blade surface should appear without defects. Defects may derive from transportation, erosion, local loads exerted as well as lightning strokes.

Damages caused by transportation shall be repaired prior to blade mounting.

Erosion defects are superficial defects caused by the surrounding environment. Thus, the wind turbine may normally operate unhindered while awaiting due course repair.

Structural main laminate defects constitute critical defects. Structural defects may be caused by local loads exerted or, in rare cases, by manufacturing defects. When a structural defect is detected on the blade, a wind turbine standstill is required, as further loads exerted on the blade may increase the defect extent considerably.

Structural defects shall be repaired before the wind turbine is put back into operation (unless agreed otherwise with LM Wind Power).

LM Wind Power shall be notified immediately after a defect is detected. LM repair instructions must be followed.

Checklist and control points to be checked according to table 8 and figure 10:

The following is checked from the lift basket:

1. Clean the drain hole in the lightning receptor at the blade tip.
2. Check the blade leading edge (B) for cracks, erosion defects and gel coat peelings.
   Check the blade to see if it shows signs of defects deriving from lightning strokes.
3. Check the blade trailing edge (A) for cracks, erosion defects and gel coat peelings.
   Check the blade to see if it shows signs of defects deriving from lightning strokes.
4. Check the blade pressure side (C), i.e. the blade side away from the tower = upwind side, for cracks, erosion defects and gel coat peelings. Check the blade to see if it shows signs of defects deriving from lightning strokes.
5. Check the blade suction side (D), i.e. the blade side towards the tower = downwind side, for cracks, erosion defects and gel coat peelings. Check the blade to see if it shows signs of defects deriving from lightning strokes.
6. Check the visible component parts of the built-in lightning conductor system to see if they show signs defects deriving from lightning strokes.
7. Check that the visible component parts of the built-in lightning conductor system are intact and firmly positioned.

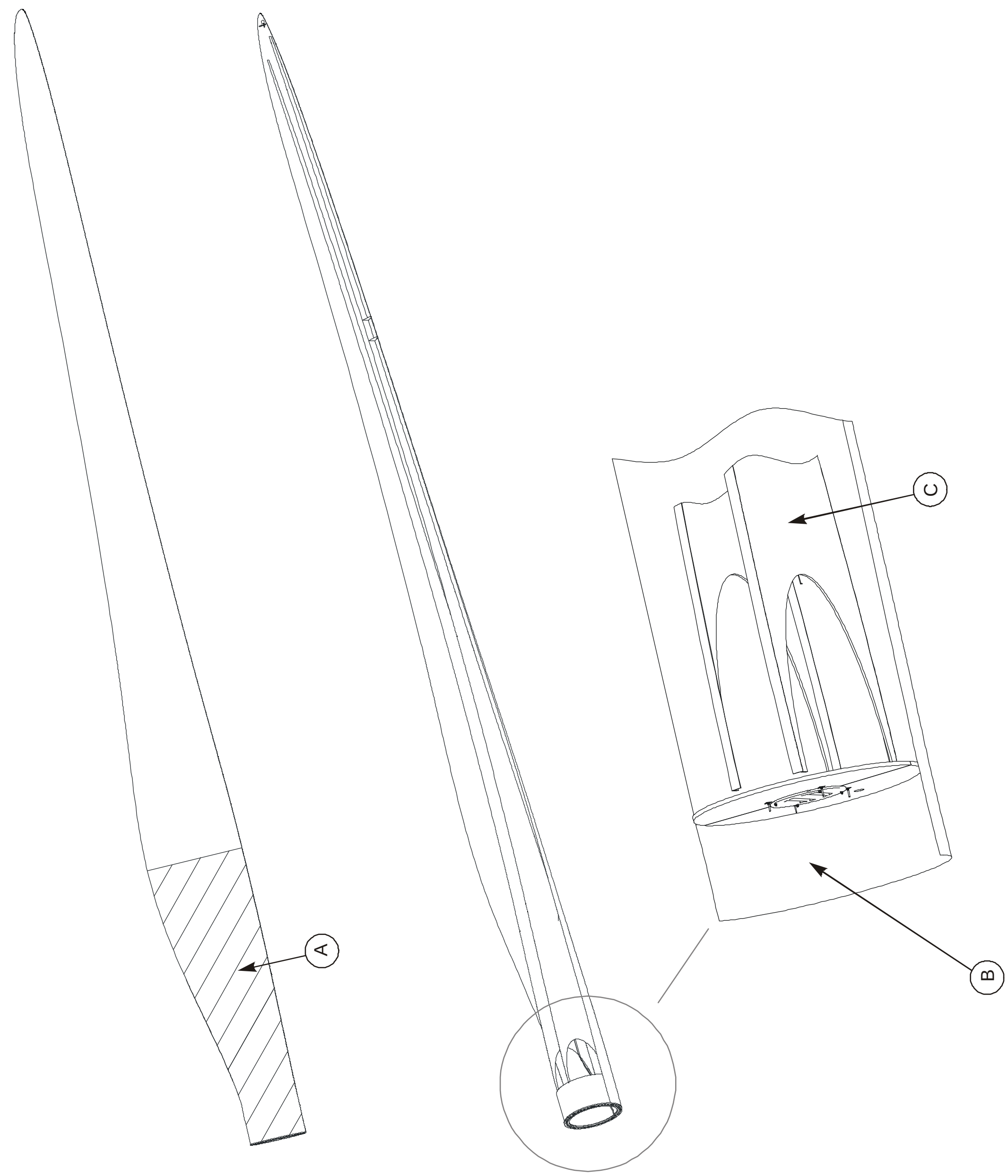

Figure 11 Maintenance of blade root area and web ends

8. Check the laminate from blade root end to maximum chord (the hatched area (A) in figure 10).
   Defects within this area could be large-sized defects. LM Wind Power must be notified about any defects detected.
9. Check the joint between the web (C) and blade shell (B) internally in the blade. Especially, the bonding of web ends should be checked. Defects within this area could be large-sized defects. LM Wind Power must be notified about any defects detected.
10. Internally in the blade, check the connection between sandwich platform and blade shell. Defects within this area should be repaired. Check that the laminate on the rear platform side appears intact.
11. Check for water inside the blade. If water appears in the blade, drain holes are checked and cleaned.

The following is checked from the nacelle:

12. Check the entire cylindrical root area for cracks, erosion defects and gel coat peelings.
13. Check that the sealing between blade and root flange appears intact.

If the sealing appears loose or buckled, the defect is repaired and filler is re-applied.

14. Check that the sealing is positioned correctly and that the plastic cover bolts are firmly tightened and secured.

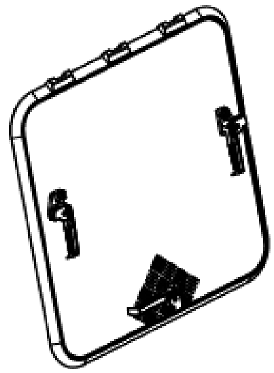

Figure 12 Hatch

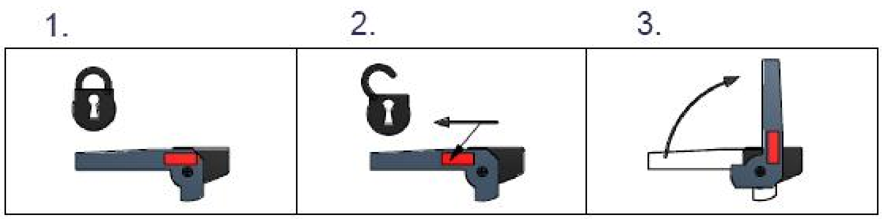

Figure 13 Three positions of the handle

1. Locked position: **The middle of the red sliding lock is next to the screw of the handle**

2. **Closed but unlocked position:** The red sliding lock has now been moved away from the screw of the handle

3. **Open position:** In position ˝unlocked˝ the handle can be turned 90º into ˝open˝ position˝

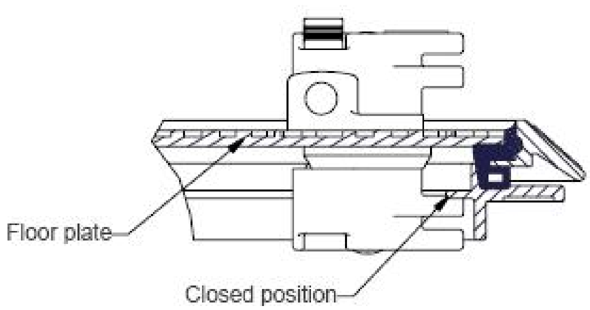

Figure 14 Hatch system

6.4 OPENING AND CLOSING HATCH IN ROOT BULKHEAD

In the root bulkhead a hatch (see figure 12) is mounted to allow inspection inside the blade.

Label is applied on the hatch frame at each handle.

How to open the hatch:

1. Place the red sliding lock in position “unlocked” - applies to all 3 handles
2. Turn the handles 90º into position “open” – applies to all 3 handles
3. The hatch can be opened

How to close/lock the hatch:

1. Before closing the hatch the handles must be in position “open” and the red sliding lock in position ˝unlocked˝- applies to all 3 handles.
2. Turn the handles 90º into position “closed”- applies to all 3 handles. To make sure that the handles are correctly engaged in the lower frame, press the floor plate whilst turning the handles - see figure 14.
3. Place the red sliding lock on the handles in position “locked”.

NB! It is important that the rubber list and the area it seals against are completely clean to secure a good seal.

6.5 LIGHTNING CONDUCTOR SYSTEM

Service inspection of lightning conductor system

Where lightning strikes, the lightning receptor is exposed to very high temperatures capable of vaporising some of the lightning receptor material. Thus, lightning receptors are shaped and mounted as to meet replacement requirements.

Lightning conductor system must be checked after 12 months of operation and then again every 12 months (see Table 8).

The vaporisation process of the lightning receptor material causes the gelcoat nearby to blacken. Normally, this does neither damage the gelcoat layer nor the underlying laminate, and it can be removed using a fine-grained polish. The blackening disappears or is washed off due to different weather conditions.

The blackening pattern depends on the situation at which the lightning strike occurs. Thus, the blackening will appear as a retreating fan when the blade is struck in operation and as a ring around the lightning receptor when the blade is struck at blade standstill.

It is not possible to determine a fixed interval for lightning receptor replacements, as the vaporisation process of the lightning receptor material largely depends on the following conditions; time duration of the lightning stroke, lightning current amplitude, energy content, and the geographical intensity in the respective area. Thus, a lightning receptor replacement is determined by an LM blade service technician examining the physical condition of the lightning receptor.

Replacement parameters for the LM blade service technician are as follows:

1. Sharp edges on the lightning receptor surface will result in a considerable noise level when the wind turbine is operating.
2. The lightning receptor surface is reduced to 70% of its normal volume.
3. The lightning receptor surface has been struck by lightning and a part of the receptor is vaporised to or below the blade surface.

At first, the inspection can be performed from the ground using binoculars to highlight the extent of the damage. On the basis of this visual inspection, further lightning receptor inspections or replacements can be made.

Lightning receptor replacement

Check lightning receptors and the surrounding blade surface for defects deriving from lightning strokes.
A blade surface blackening can be removed using a fine-grained polish.
Contact LM Wind Power for further instructions in the event that laminate defects are caused by lightning strokes.

Lightning receptor replacement should be performed according to the below points no. 1-6 for the receptors and 1-3 for the drainage receptor.

The following tools should be used; special tool for lightning receptor removal, socket-head screw wrench, drilling machine and a steel bit, degreasing agent, emery paper and filler.

Receptors:

1. The defective lightning receptor is removed from the blade using a special tool to be supplied by LM Wind Power. Use the 2 small holes in the upper lightning receptor surface. Two new holes are drilled in the event that the 2 small-sized holes are defective.
2. The old filler inside the lightning receptor hole is removed. Then the hole is thoroughly degreased.
3. The new lightning receptor is ground to a mat finish on all of its sides. Then the sides are thoroughly degreased.
4. Lightning receptor is mounted in the thread and tightened by means of the special tool and a torque wrench at 20 Nm. Use the 2 small holes in the upper lightning receptor surface.
5. The gap between the lightning receptor and blade as well as the 2 lightning receptor holes are applied with filler. Gap and lightning receptor holes should be filled completely in order to avoid air bubbles beneath the surface. Any excess filler is removed.

Drain receptor:

1. The drain receptor at the very tip end is removed by using a socket-head screw wrench.
2. Inspect drain receptor hole, use cleaning fluid to degrease the drain receptor and hole. Cleaning fluid should evaporate prior to final mounting.
3. The drain receptor is applied at a moment of 20Nm until having a projected length of 2 ± 0.5 mm. Otherwise adjust the drain receptor to reach the projected length specified.

If the use of a drainage receptor isn`t desired, 3 drain holes and/or diverter component parts require maintenance.

1. Check that drain holes are trough going and free from dirt. Use cleaning fluid to degrease the drain holes.
2. If diverter is mounted, the maintenance is described in the section “Features”.

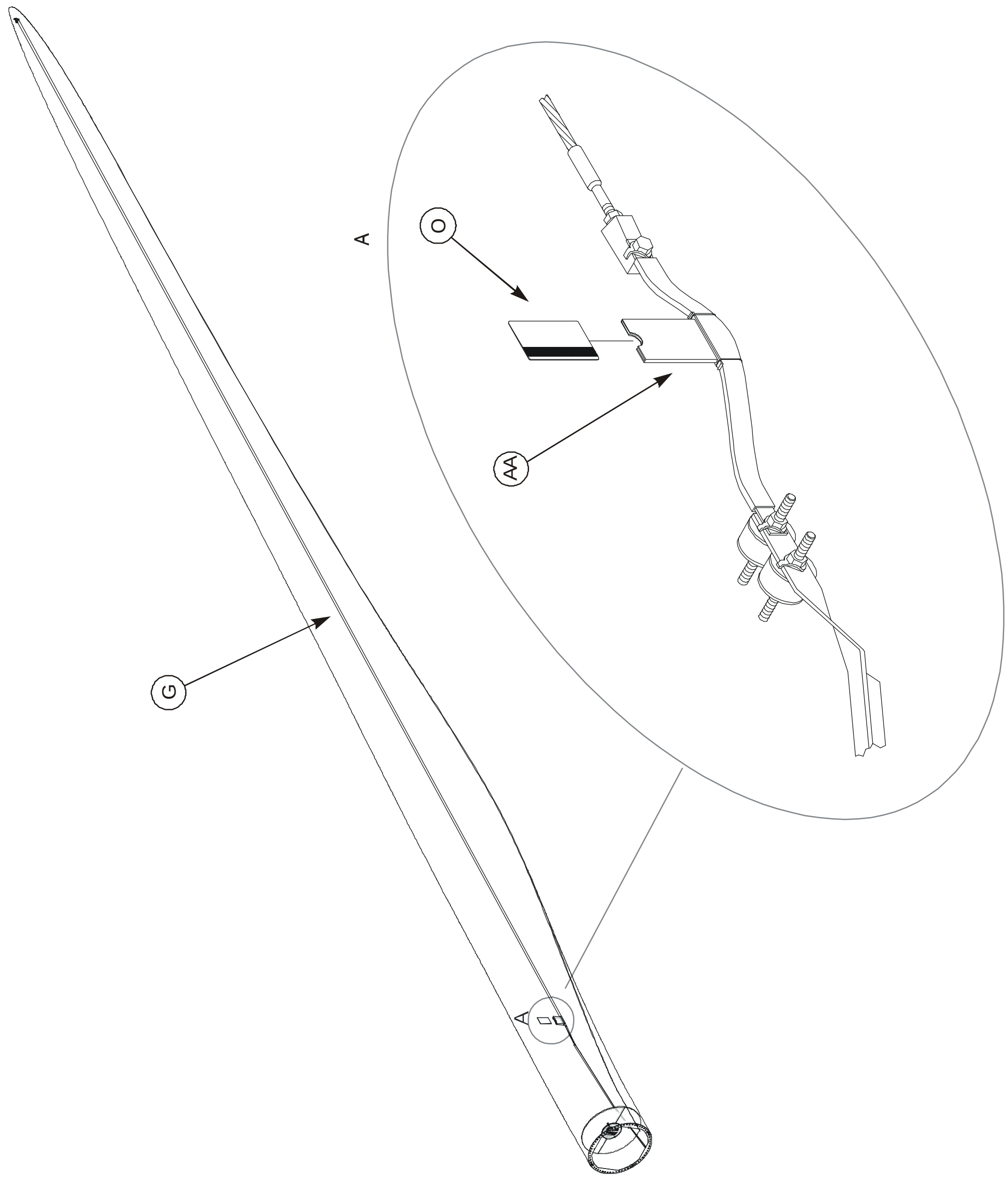

Figure 15 Card holder for lightning conductor system

Replacement of lightning registration card

Lightning registration card removal and reading:

1. Use a thumb and index finger to turn the lightning registration card clockwise in order to loosen it from the internal locking pins. Then the lightning registration card can be removed from the card holder (see (AA) in figure 15).
   If the lightning registration card is removed from the card holder without turning and loosening it from the locking pins, the card will most likely damage the locking pins making them unable to fasten the next card applied.

2. Complete the information on the lightning registration card.

3. Lightning registration card is sent to the following address for data recording:

LM Service

Industriestrasse 5

D-39291 Schopsdorf

Germany

After having recorded the lightning registration card information, the LM Service Department will send you a written reply. A new lightning registration card can be ordered at the above-mentioned address.

Lightning registration card is equipped with two magnetic stripes on one card side. The magnetic stripes are sensitive to magnetism. Thus, the card should be handled as follows:

1. Lightning registration card should not be magnetically induced, e.g. by means of magnets or welding equipment.
2. Keep the lightning registration card min. 30 cm away from mobile phones, radios, speakers, electrical tools, screwdrivers, etc.
3. Lightning registration card should not be mechanically induced, e.g. by means of scratches, tapping and bending, as this could damage the magnetic stripe.

Preparation of a new lightning registration card:

1. Fill out the text fields on both sides of the card.
2. Card information is written with waterproof ink.
3. Lightning registration card is inserted completely into the card holder, until the locking pins fasten it.

6.6 FEATURES

If any features, as defined in customer specification, are mounted on the blade surface they must be checked after 12 months of operation and then again every 12 months (see Table 8).

As to optimise business economics and reliability of operation, the features must appear without defects. Defects may derive from transportation, erosion, local loads exerted as well as lightning strokes.

Transportation defects should be repaired prior to blade mounting.

Erosion defects are superficial defects caused by the surrounding environment. Thus, the wind turbine may operate unhindered prior to being repaired.

All defects on features must be repaired. LM Wind Power A/S must at once be notified about any defects detected. LM repair instructions should be followed.

Checklist and control points to be checked according to Table 8:

If mounted, features are checked from the lift basket for the following:

1. Check that features are intact and firmly positioned
2. Check that glue joints on features are intact
3. Check that sealing of features is intact