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Transport Manual

V90 - 3.0 MW

Guiding Information on
Minimum Requirements of Transport

WWW.VESTAS.COM

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TRANSPORT GUIDELINES
VESTAS V90 - 3.0MW

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1. Introduction

These transport guidelines (“The Guidelines”) describe in very general terms certain aspects of the civil engineering works to be constructed on a wind energy project site.

The guidelines may be subject to amendments without notice and are not verified to be correct and complete and are not a sufficient basis for the preparation of a design or construction of such civil engineering works or for any other purpose.

In no event shall Vestas or its distributors be liable under warranty, or any other legal theory, whether based in contract or tort (including without limitation negligence), for incidental, consequential, indirect, special, or punitive damages of any kind, or for loss of revenue or profits, loss of business or other financial loss, cost or expenses, arising out of, or in connection with, the carrying out of any of the activities described in these guidelines, whether or not such activities are carried out in accordance hereto.

Vestas should be contacted directly if the guidelines are to be used for any other purpose than merely as a description of certain related aspects.

2. Preface

Please note that details of measurements and weights of individual turbine components may be superseded by information in the General Specification for the turbine type in question.

For information about turbine installation procedures, please contact our Service Department.

Terms in Use

For the purpose of these guidelines, the term “*route*” refers to the route taken to move component parts from the factory, or port of entry, to the entrance to the wind farm site.

“*Public road*” refers to any road which is maintained by the local authorities and is in common use by the travelling public, in urban or rural areas. All classes, M, A, B and C, are included.

“*Access road*” refers to a road, existing or purpose-built, which leads from any public road system to the site.

“*Site road*” refers to any road built to carry traffic from the site entrance to the crane pads, sub-station or compound within the wind farm boundaries.

The structure of access and site roads generally depends on the topography at the site.
Different designs may be adapted to suit the prevailing ground conditions.
The movement of heavy cranes as well as abnormal load transport must be taken into consideration.

All access roads and site roads should be constructed and maintained in accordance with the specifications in this document.

3. Public Roads

Prior to commencing construction, a route survey must be carried out to ensure that trouble-free and timely delivery of the large components is possible.

Route Survey

In conjunction with a selected transport contractor, Vestas transport staff will conduct a preliminary route survey and plan for the most efficient route from a suitable port of entry near the site to the entrance of the wind farm.

Consultations are held with the local authorities to determine the volumes of local traffic, peak times and pinch points. Such things as environmental issues, tourist traffic and any road works, as well as the proximity of schools and housing estates are also considered.

The route survey supplied by Vestas provides information on what is then considered to be the most suitable route to the site, minimising local disruption, but maximising the smooth flow of supplies to the site.

Road Survey

Prior to any commitment, a road survey must be carried out to ensure a successful and trouble-free delivery.

When the route has been selected, a road survey is conducted and the chosen route is carefully examined to ensure that abnormal loads can pass without difficulty.
Pinch points are noted, documented and photographed for accurate identification.
A swept path analysis is sometimes used to determine whether certain traffic could theoretically pass narrow or tight spots. A test run at a later stage would confirm whether certain loads can pass these pinch points.
A traffic management plan is drafted for approval by local authorities.

During a road survey, it is important to note the following:

- Use detailed maps.
- Axle load and gross train weight limits on roads and bridges.
- The radius and road width at curves, bends, junctions and traffic circles.
- The gradient of inclines and declines.
- The horizontal radius of dips and bumps in the road, at bridges and level crossings.
- Width and height under road and railway bridges and viaducts.
- Clearance under overhead lines and gantries.
- Lay-by areas that can be utilised for temporary parking and lay-bys that can be used to let traffic pass slow moving abnormal loads.
- Any other obstruction that may restrict the transportation.

Always keep weather conditions in mind; the effect of these may have a harmful influence on the proposed route.

Urban Areas – Town Centres, Public Roads, Local Works or Structures

It is always assumed that the developer will apply for permission from local authorities to take down street furniture, divert traffic and establish lay-by areas etc. It will also be the developer's responsibility to negotiate with local landowners in case it is necessary to utilise part of their land to widen roads at selected spots to enable heavy transport to negotiate tight bends and narrow junctions en route to the site entrance.

Street Furniture

If a large project is to be built over a period of time, the use of "demountable" street furniture should be considered. Street furniture can be laid down at the approach of an abnormal load vehicle by the pilot car's crew to allow the passage of heavy loads and then re-erected immediately after the load has passed by the tailing car's crew.

An alternative is to discuss the permanent re-siting of some street furniture at troublesome pinch points with the local authorities. This often involves no more than moving a sign a metre or two in a certain direction, which may be sufficient to permit safe passage, but still retains the traffic management function of the sign or light concerned.

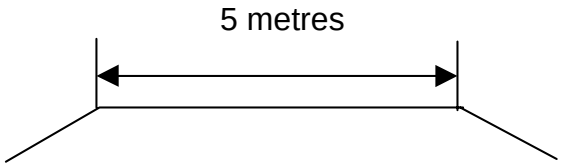
4. Site Roads

Site Access
The site entrance/access must comply with requirements illustrated in figure 1A (attached).

Load Capacity
The load bearing capacity of all site roads must be no less than 15 tons per axle, and a compaction of 95% must be obtained as well.

The thickness of the wearing course material should be a minimum of 300 mm to ensure that there is enough material for grading the site roads during both the civil engineering and the wind farm construction phase (and for later service access), without disturbing the base material. The thickness of the sub-base depends on the underlying soil - a soil analysis may be necessary. Geotextile must be used where base material is likely to sink into underlying soft soils or peat.

Road Width
All site roads must have a minimum road width of 5 metres on the crown. The base must be built to suit the ground conditions.

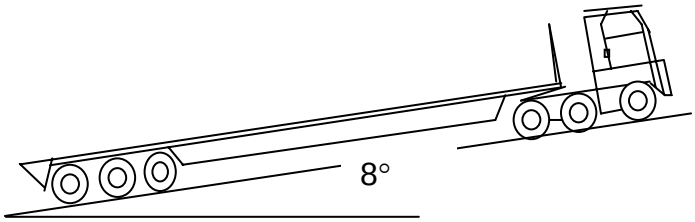


The 5 m crown width is designed to accommodate the movement of cranes, as well as trailers.

The new generation of crawler cranes can travel on well made 5 m wide roads and handle the same gradients as mobile cranes when fully rigged.
If a standard crawler crane is to be used, all site road areas adjacent to one or more turbines (a string of turbines) must be a minimum of 7 m in width.

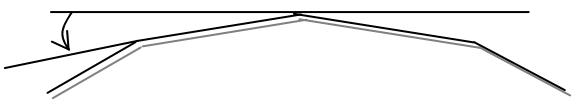
Overhead Clearance
All roads must be clear of overhead obstructions, i.e. power lines, to a minimum height of 5 metres to allow the passage of high loads. All overhead obstructions must be clearly marked with bunting and a gauge to indicate maximum height.

Slope and Grade
No access or site roads should have a grade exceeding 8°, corresponding to 14%.



Gradients in excess of 8° are subject to approval by Vestas, Haulier and the crane company. Special arrangements for towing vehicles have to be made in these cases. This is based on drained roads consisting of crushed rock and stone with a top layer corresponding type 1 material.

The maximum lateral grade must not exceed 2°.



Drainage

Good drainage is the secret of success on all roads. It is essential to ensure that the side drains are deeper than the sub-base to carry off the water, thus preventing flooding of the road foundation (sub-base). The lateral slope allows surface water to drain away without eroding the wearing course.

Water should be drained to surrounding fields or off to a water course near the site. Adequate provision must be made in respect of environmental issues.

Material

Sub-base material must be graded road stone.

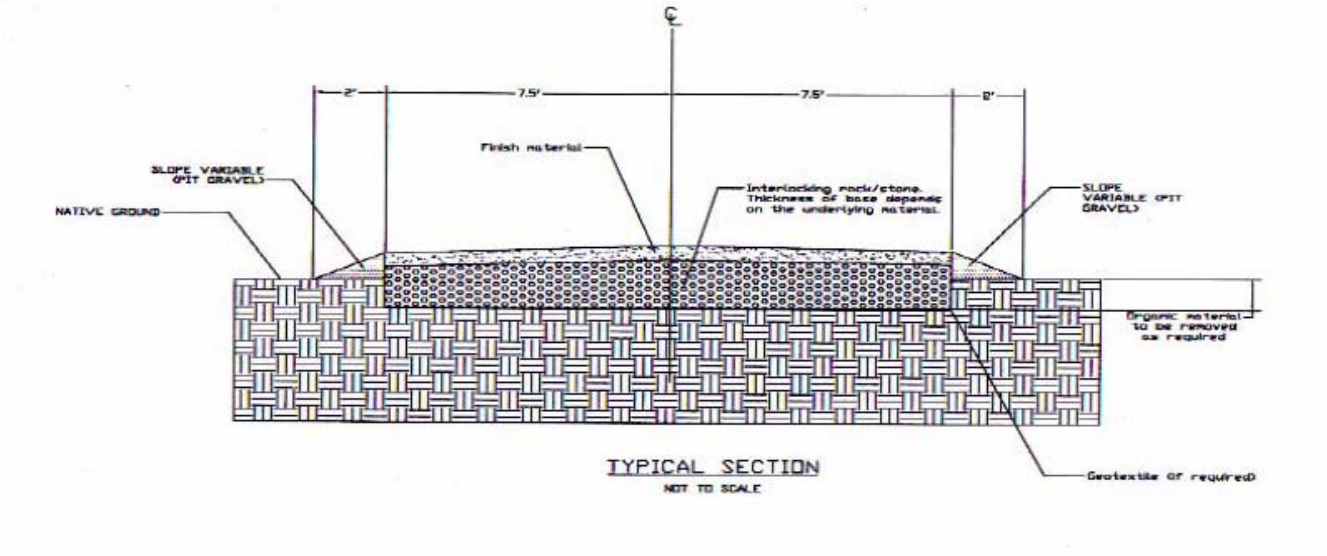
The wearing surface must be compactable type 1 material.

This illustration shows what can happen if clay or incorrect materials are used as part of the road construction.

Maintenance Bump, Dips and Lay-bys

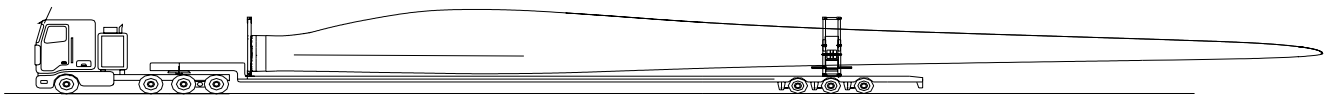
The roads must be maintained, graded, watered etc. throughout the duration of the construction phase and installation period to prevent surface deterioration.

Typical cross section of a site road.



Convex and Concave Longitudinal Radii

At lengths approaching 56 m, a blade trailer and tractor require a 200 m longitudinal radius (convex or concave) to avoid the risk of grounding or dragging.



There should as a minimum be lay-bys at every one (1) kilometre of the site as well as at critical points of the site roads. The lay-by must be 60 metres long and 5 metres wide in order to accommodate blade trailers or tower base sections safely.

Delivery Requirements

Delivery	*****	*****
Parameter	**Units**	**Value**
Access Road Minimum Width (Straight roads)	m	5
Access Road Minimum Bend Radius		
Access Road Maximum Longitudinal Slope	degrees	8
Access Road Maximum Lateral Slope	degrees	0-2
Access Road Minimum Specifications (axle load)	metric ton	15
Access Road Longitudinal Radius (convex or concave)	m	200

Gradients in excess of 8° (1:7, 14%) are subject to acceptance by Haulier and the crane hire company.

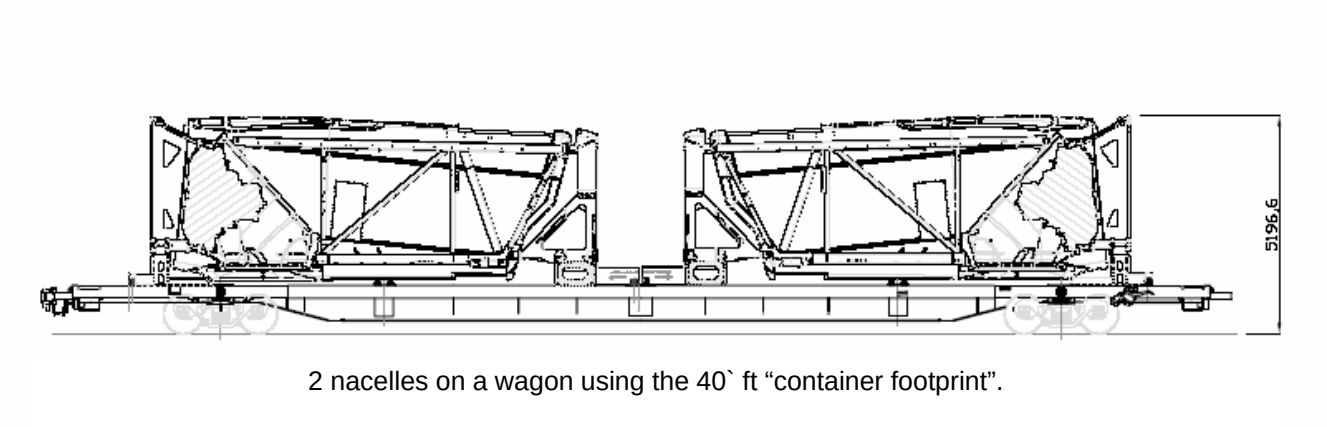
Transport on Road with Truck

The transport will typically consist of the following:

Quantity	Description
1	Float loaded with complete nacelle
1 or (3)	Extendible trailer for blade transport (1 if triple trailer is used or 3 for single blade frame)
3 or (5)	Trailers for towers
1	Trailer loaded with cables/controllers
1	Trailer with blade hub
1	Trailer loaded with 40 ft container with tools and generator for installation

5. Transport by Train (US only)

The only possible way to ship the V90 (44m) blade on train is with the single blade frame.



2 nacelles on a wagon using the 40` ft “container footprint”.

Maximum Dimensions on Rail:

Maximum height above rail: 20` (ft) / 6.09 m
Maximum width: 13` (ft) / 3.96 m - It is possible to get a dispensation up to 13` (ft) 4`` (inches).

6. Transport Overseas

The transport will typically consist of the following:

Quantity	Description
1	Complete nacelle
1	Blade hub (in a 20` ft container)
3 or (2)	Blade frames with blades (or containers)
3 or (5)	Tower sections (3 sections for 80m IEC or 5 sections for 105m DIBT ll)
1	40 ft container loaded with cables/controllers etc. (within legal limits)
1	40 ft container loaded with tools and generator for installation

Sea Transport

According to the Vestas Group Insurance policy, we hereinafter refer to the following:

The marine transit rates agreed for this insurance apply only to cargoes and/or interests carried by mechanically self-propelled vessels of steel construction, classed by classification societies (to be informed upon request). Provided such vessels are:

a) (i) not bulk and/or combination carriers over 10 years of age.
(ii) not mineral oil tankers exceeding 50,000 GRT which are over 10 years of age.

b) (i) not over 15 years of age, OR
(ii) over 15 years of age but not over 25 years of age and have established and maintained a regular pattern of trading on an advertised schedule to load and unload at specified ports.

General Guidelines for Distribution and Stowing of "Deck Cargo"

"Deck cargo shall be so distributed and stowed –

(1) as to avoid excessive loading having regard to the strength of the deck and integral supporting structure of the ship;
(2) as to ensure that the ship will retain adequate stability at all stages of the voyage having regard in particular to -
  (a) the vertical distribution of the deck cargo;
  (b) wind moments which may normally be expected on the voyage;
  (c) losses of weight in the ship, including in particular those due to the consumption of fuel and stores; and
  (d) possible increases of weight of the ship or deck cargo, including in particular those due to absorption of water and to icing;
(3) as not to impair the weather tight or watertight integrity of any part of the ship or its fittings or appliances, and to ensure the proper protection of ventilators and air pipes;
(4) that its height above the deck or any other part of the ship on which it stands will not interfere with the navigation or working of the ship;
(5) that it will not interfere with or obstruct access to the ship`s steering arrangements, including emergency steering arrangements;
(6) that it will not interfere with or obstruct safe and efficient access by the crew to or between their quarters and any machinery space or other part of the ship used in working of the ship, and will not in particular obstruct any opening giving access to those positions or impede its being readily secured weather tight."

Lashing and Securing of Deck Cargoes:

Determination of MSL (**M**aximum **S**ecuring **L**oad) from breaking strength with **R**ule **O**f **T**humb multipliers.

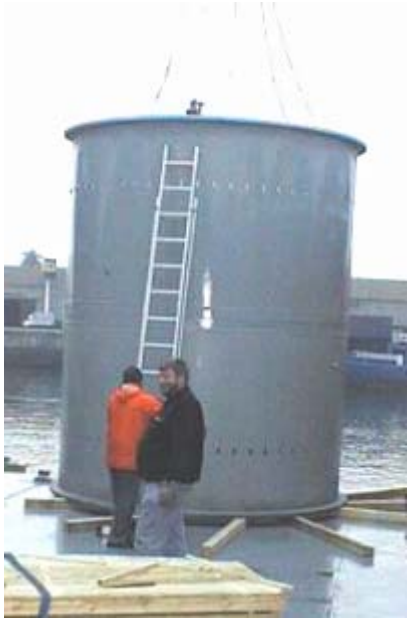
Material	MSL	R.O.T. Multiplier
Shackles, rings, deck eyes, turnbuckles of mild steel	50% of breaking strength	4
Fibre rope	33% of breaking strength	6.06
Wire rope (single-use)	80% of breaking strength	2.5
Web lashing	50% of breaking strength	4
Wire rope (re-useable)	30% of breaking strength	6.67
Steel band (single-use)	70% of breaking strength	2.86
Chains	50% of breaking strength	4
(Compare with overall general component)	*(66.6% of breaking strength)*	*(3.00)*

Cargo Mass x Rule Number = Lashings Total Breaking Strength.

Transport - Foundation Insert

Foundation Weights		
Section	**Item no.**	**Weight in kg**
Foundation V90 80m IEC (3 sec)	759354	15390
Foundation V90 105m DIBT II	759396	27450
Lifting equipment / brackets		200

Foundation Dimensions		
Section	**Max. diameter (mm)**	**Length (mm)**
Foundation V90 80m IEC (3sec)	4550	2300
Foundation V90 105m DIBT II	4675	2440



Transportation of Inserts:
The foundation insert can be loaded on either its base flange or shell side. Double stacking is possible using the flanges.
The preferable orientation is on its base flange, as it facilitates later unloading.
Transport can be done either by truck, rail or barge.

Lashing and Securing of Foundations

To minimise lashing damage on the coated surface it is possible to use a piece of webbing.

The ”inside” chain lashings are fastened to the deck using turnbuckles to the weld-on ”D-rings”.
Notice that the timber dunnage is spread equally on the deck.

Steel ”knees” welded on the deck to prevent any movement of the foundation.

7. Transport of Towers

Tower Dimensions 80M			V90-3.0MW / DS 472
	Top end	Bottom end	Total length
Section / No.	Ø (mm)	Ø (mm)	(mm)
Top section / 4	2316	2773	23285
/ 3	2773	3284	20500
/ 2	3284	3807	20355
Base section / 1	3807	4190	13350

Tower Weights 80M			V90-3.0MW / DS 472
	Total Weight	C of G	Reaction in A / B
Section / No.	(Kg)	mm from low.fl.	A (Kg)	B (Kg)
Top section / 4	29500	11285	15000	14500
/ 3	33000	8528	19000	14000
/ 2	47500	8335	28000	19500
Base section / 1	52500	5484	30500	22000

Flange Dimensions 80M				V90-3.0MW / DS 472
	Bolt circle Ø	Hole Ø	Holes	Thickness of
Flange assembly / No.	(m m)	(mm)	No.	flange (mm)
Top flange / 5	2160	33	90	250
Intermediate flange / 4	2631	39	92	90
Intermediate flange / 3	3120	45	108	115
Intermediate flange / 2	3630	45	128	125
Bottom flange / 1	4000	45	140	130

Tower Dimensions 80M			V90-3.0MW IEC 1A
	Top end	Bottom end	Total length
Section / No.	Ø (mm)	Ø (mm)	(mm)
Top section / 3	2316	2821	29085
/ 2	2821	3488	29005
Base section / 1	3488	4190	19210

Tower Weights 80M			V90-3.0MW IEC 1A
	Total Weight	C of G	Reaction in A / B
Section / No.	(Kg)	mm from low.fl.	A (Kg)	B (Kg)
Top section / 3	38000	14415	19000	19000
/ 2	55500	?	30000	25500
Base section / 1	60500	8288	34000	26500

Flange Dimensions 80M				V90-3.0MW IEC 1A
	Bolt circle Ø	Hole Ø	Holes	Thickness of
Flange assembly / No.	(m m)	(mm)	No.	flange (mm)
Top flange / 4	2160	33	90	250
Intermediate flange / 3	2680	36	100	110
Intermediate flange / 2	3320	45	108	130
Bottom flange / 1	4000	45	140	130

Tower Dimensions 105M			V90-3.0MW DIBT II
	Top end	Bottom end	Total length
Section / No.	Ø (mm)	Ø (mm)	(mm)
Top section / 5	2314	2819	29135
/ 4	2819	3485	29055
/ 3	3485	4173	19260
/ 2	4173	4175	15000
Base section / 1	4175	4198	10000

Tower Weights 105M				V90-3.0MW DIBT II
	Total Weight	C of G	Reaction in A / B	
Section / No.	(Kg)	mm from low.fl.	A (Kg)	B (Kg)
Top section / 5	33500	14347	17000	16500
/ 4	51500	13524	27500	24000
/ 3	46000	9171	24000	22000
/ 2	42000	7296	21500	20500
Base section / 1	48000	4448	26500	21500

Flange Dimensions 105M				V90-3.0MW DIBT II
	Bolt circle Ø	Hole Ø	Holes	Thickness of
Flange assembly / No.	(m m)	(mm)	No.	flange (mm)
Top flange / 6	2160	33	90	200
Intermediate flange / 5	2675	39	100	100
Intermediate flange / 4	3330	45	116	125
Intermediate flange / 3	3990	45	140	130
Intermediate flange / 2	3990	45	140	140
Bottom flange / 1	3990	45	140	150

Loading of Towers

Lifting bracket, shipping bracket and eye-lets are delivered by the tower manufacturer.
Chains, hooks and other devices for lashing and securing are not part of Vestas delivery.

Properly designed lifting brackets must be used for lifting the tower sections onto the trailer, ship etc.

Tower section handled with slings.
To prevent damage on the coated surface, the slings are wrapped with plastic.

Transportation of Towers

Road, rail and barge

Tower sections are transported individually using low-bed or drop deck trailers. The truck/ trailer combination will depend on size, weight and dimensions of the different sections.
To avoid damage to the tower surface, it will be necessary to take precautions regarding transport equipment.
Saddles made of steel must be lined with rubber and carpet.

Never allow the tower shell to maintain direct contact with sharp edges and material such as wood or steel.
Dents will occur immediately!

On special occasions such as transport on barge, it is possible to use saddles made of plywood.
In this example, the saddles are lined with carpet covered with plastic.

Tower sections can be loaded on trucks in different ways according to the national rules about axle settings and cargo lashing.
Always consider the placement of the centre of gravity and use the proper saddle support!!!

Tower sections can also be transported by rail.

NOTE !!!
There are special rules and specifications concerning the lashing and securing on rail.

The tower can be transported as a self-supporting unit provided that the proper equipment is used.

Tower section on the “New Lift adapter”

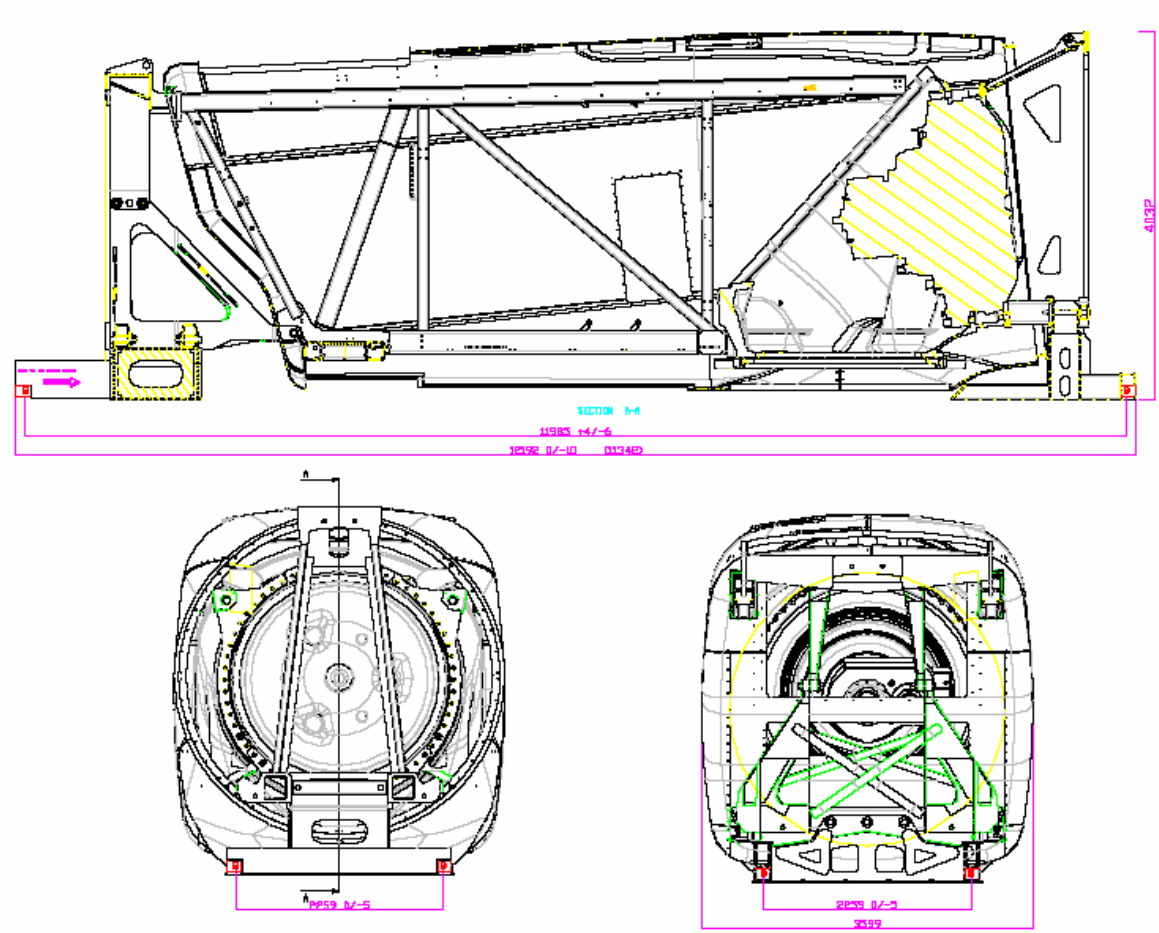
Traditional configuration of tower transport

General storage of tower sections:

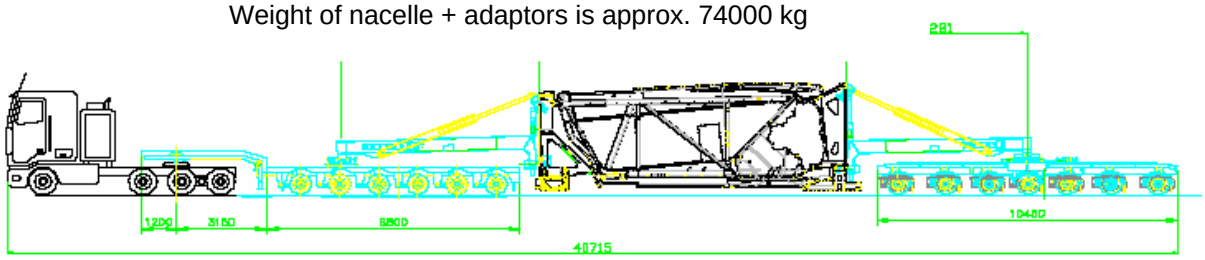
To prevent storage damage and accidents, the following precautions must be taken:

- Maintain adequate clearance between tower and ground.
- Ensure the end covers are tight.
- Restrain tower sections against rolling and sliding movements.

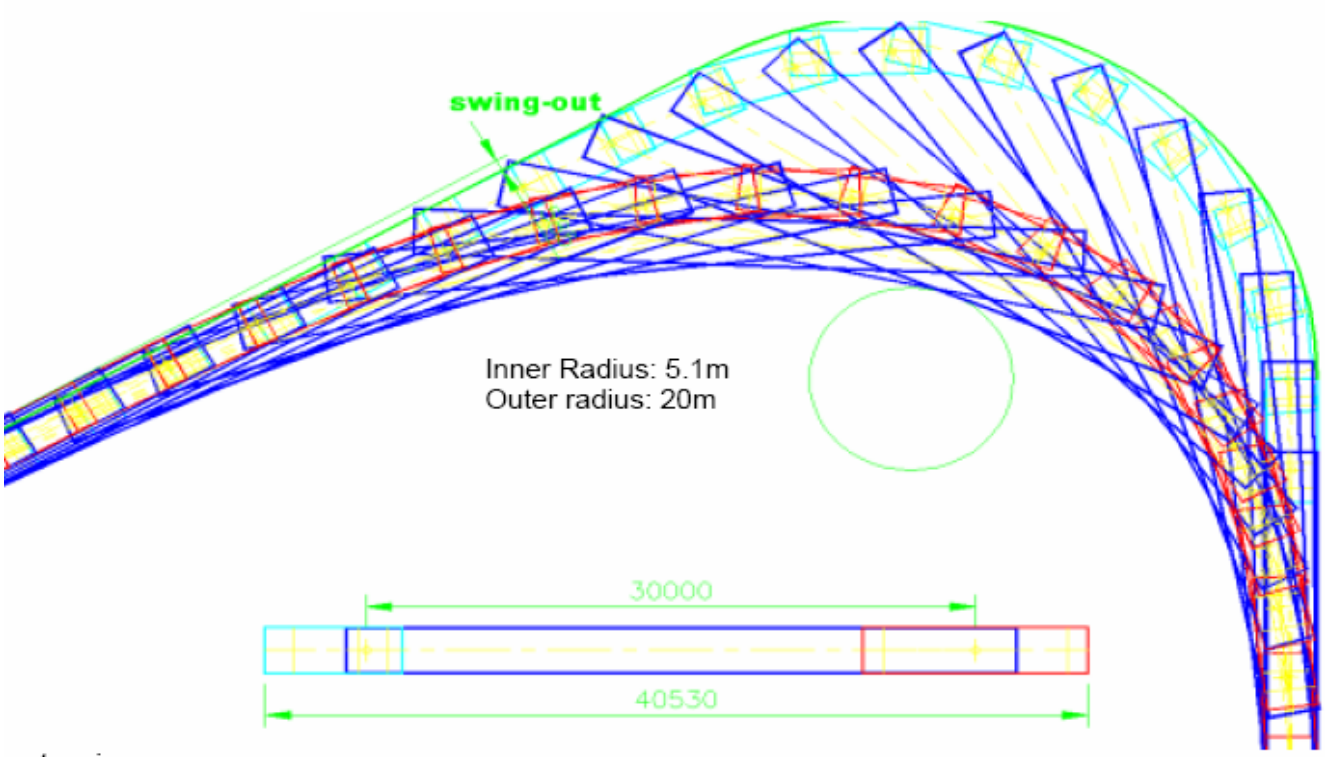
8. Transport of the Nacelle



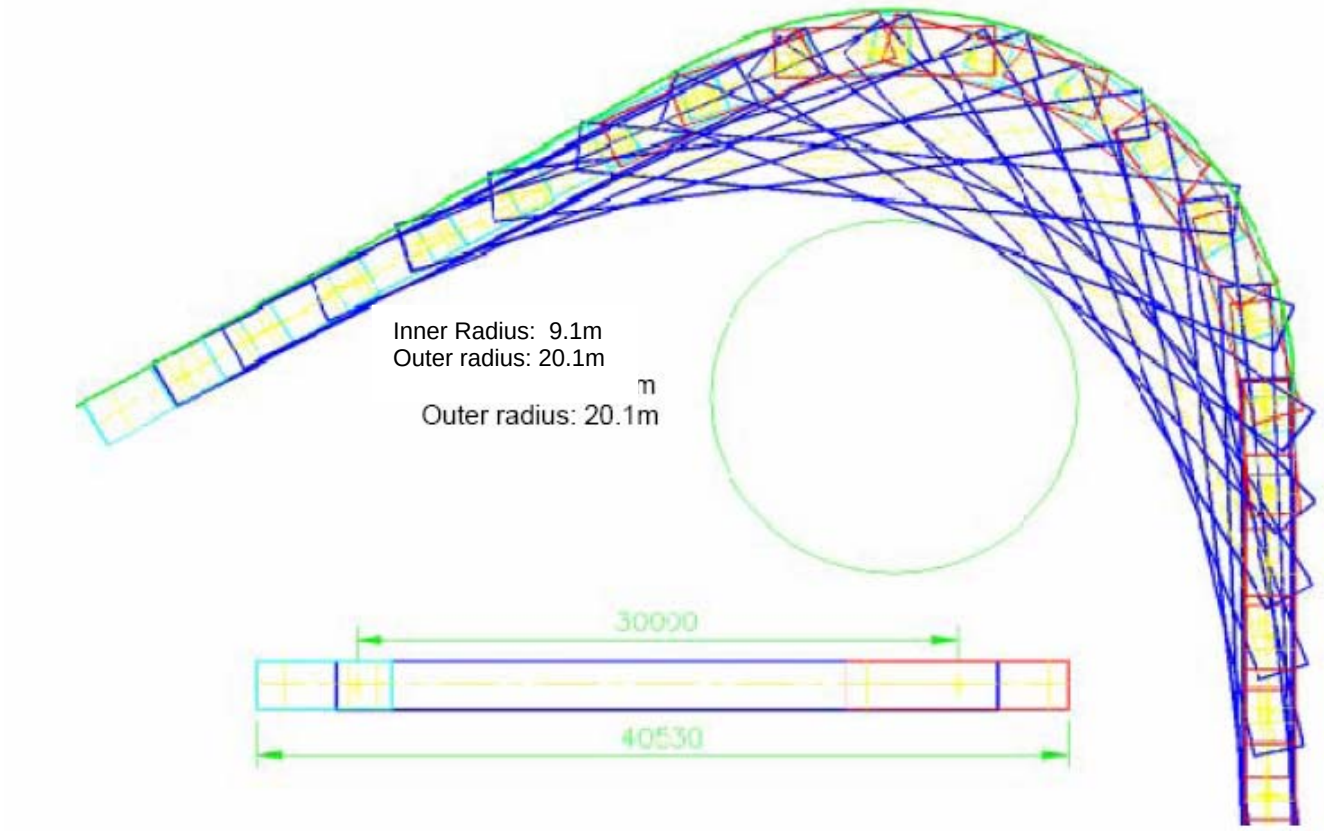
Weight of nacelle + adaptors is approx. 74000 kg



7-axle Dolly, Steering Behaviour



Automatic steering



Manual steering

The unloaded nacelle lift adapter ready for return shipment - Total weight: 52000kg

V90 nacelle geared for lifting.
The adapters are not removed from the nacelle before it is placed on top of the tower.

IMPORTANT !

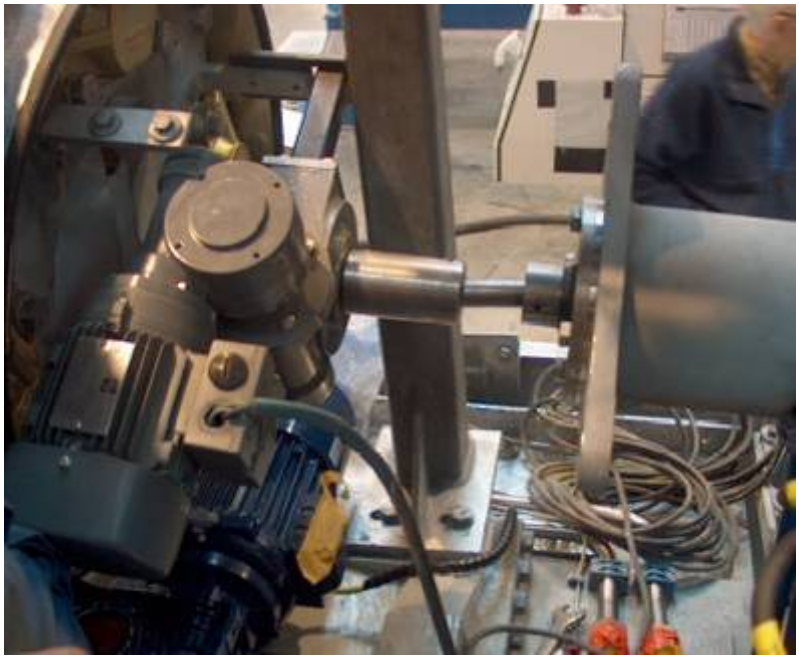
Please notice.

Handling in general:

Any hard shocks from crane, truck or train could have an unfortunate influence on the mechanical parts of the nacelle!

To avoid any potential damage of the gearbox and generator bearings, all Vestas MW nacelles bound for transport overseas or rail transport will be supplied with a "turning gear device".
It is up to the involved transport company to guarantee that the equipment has constant power supply!

Correct power:
380 - 400 V 50 / 60 Hz



Diesel generator on train, as power supply to ”turner gear device”.
(US “High Winds” Project)

9. Hub Transport

The hub for the V90 - 3.0MW is shipped in a specially designed 20` high cube container.
Total weight: 27 metric tons.

The nose cone is shipped as a separate coli:

Dimensions: 3260mm x 2920mm x 2475mm

Weight: < 600 kg

Parts Container

The parts container is a 40` OT type.

The container is loaded with the following item nos.:
2 X 761430, 780889, 781099, 781138, 781180, 782250, 786520, 786550, 786560, 787694, 809299, 809001, 747577, 114961, 106609, 194519, 808974.
The number and type of the items can change according to the size of the project.

10. Transport of Blades

Transport - Blades Single:

Weight & Dimensions		
Item	Max. dimensions (mm)	Weight (kg)
Grid frame (with blade)	L: 45160 W: 2390 H: 3330	12200
"HJ" frame (with blade)	L: 44200 W: 2438 H: 3200	8700
CFC container (with blade)	L: 44688 W: 2438 H: 3300	34700

"Grid frame" normally used for service purposes.
Weight: approx. 5 t.
The five sections of the frame can be collapsed
and put in a 40 ft container for return shipment.
It is not possible to double-stack this type of frame on a ship.
The frame needs two cranes in lifting.

The simple "HJ frame" is competitive to the CFC con-tainer.
Weight: approx. 900kg.
There is space enough for 13 of these frames in a 40 ft container for return shipment.

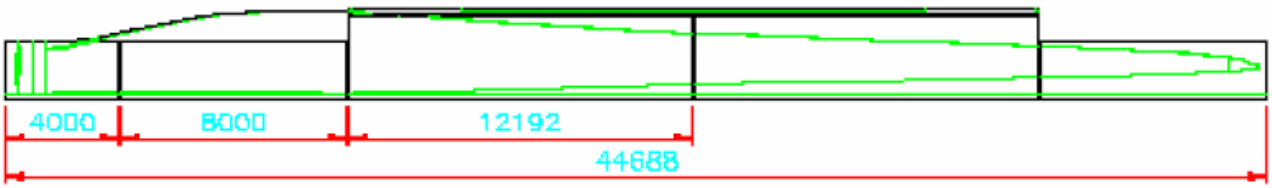
Double-stacking is possible with ordinary twist locks and bridge fittings.

Blades in ”HJ frames” can be handled with crane in three different ways:

- With one crane using an 80` spreader
- With two cranes
- With two cranes using an 80` spreader

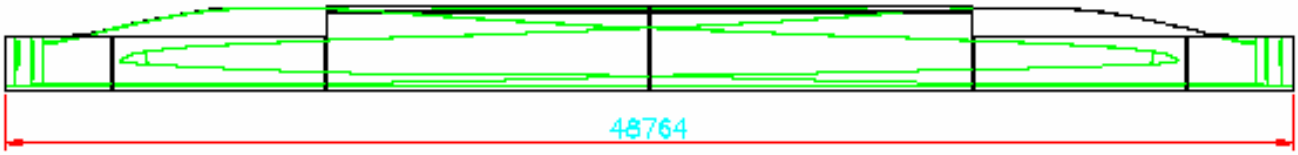
(as in the picture - the safe way)

A single blade transport in the "CFC" container is possible but rarely used. Weight: approx. 27.5 t. The return shipment is by 2 40 ft containers.



Transport - Blades Double:

Weight & Dimensions		
Item	Max. dimensions (mm)	Weight (kg)
CFC container (with 2 blades)	L: 48764 W: 2438 H: 3300	40000

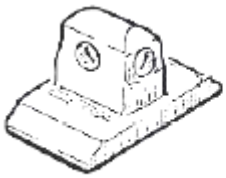


The CFC container is the only equipment which is able to carry 2 blades at a time. Weight: approx. 28 t. Return shipment is by 2 40 ft HC containers.

V90 blade in "Grid Frame". Discharged in Portugal 2003.

The CFC container placed on deck.

Securing of Blade Containers



MacGregor type: SC-1P SL-1

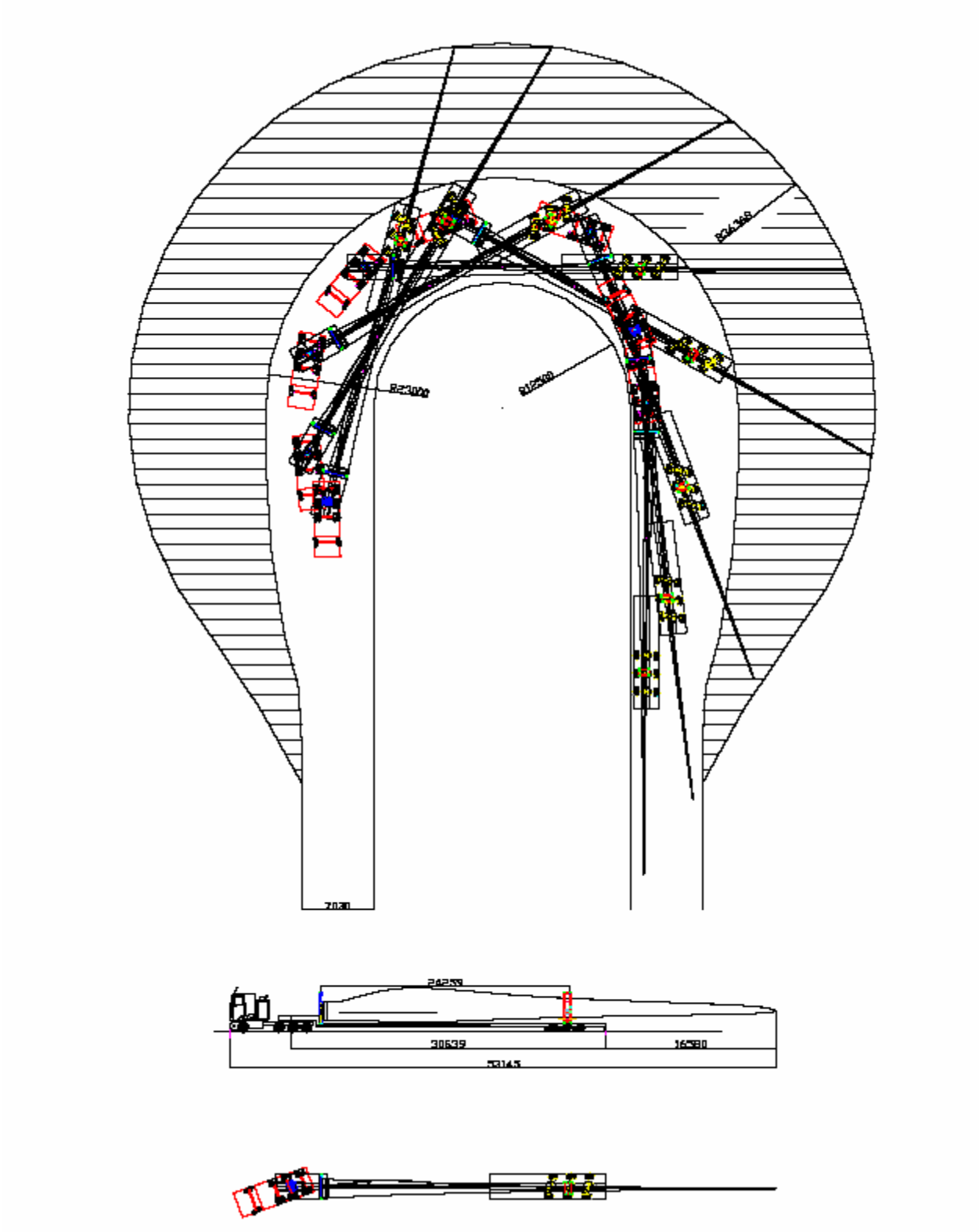
It is not possible to secure the Vestas CFC blade container (loaded) with ”traditional” twist locks - due to the connecting “quick tie” between the container sections.
The MacGregor lockable stacking cones (SC-1P + SL-1) are fit for the purpose.

When a “quick tie” is used in the bottom corner casting, it takes up so much space that a twist lock can not be twisted to a locking position.

11. Transport on Road with 44m Blade

Radius required for telescopic trailer with electric/hydraulic, manually controlled rear steering wheels.

Inner radius: 12.5 meter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