

Tilsyn – Offshore vindmøllefundamenter



Agenda

1. Projektreferencer
2. Konstruktionsprincipper
3. Tilsyn med produktion
 - Tilsynsplan
 - Eksempler
4. Tilsyn med installation
 - Tilsynsplan
 - Eksempler
5. Evt. spørgsmål



2



Projektreferencer

3

- Middelgrunden vindmøllepark (1999-2000)
 - 20 vindmøllefundamenter FUK op til -8,0 m
- Rødsand 2 vindmøllepark (2009-2010)
 - 90 vindmøllefundamenter FUK op til -12,5 m
- Kårehamn vindmøllepark (2012-2013)
 - 16 vindmøllefundamenter FUK op til -20,3 m

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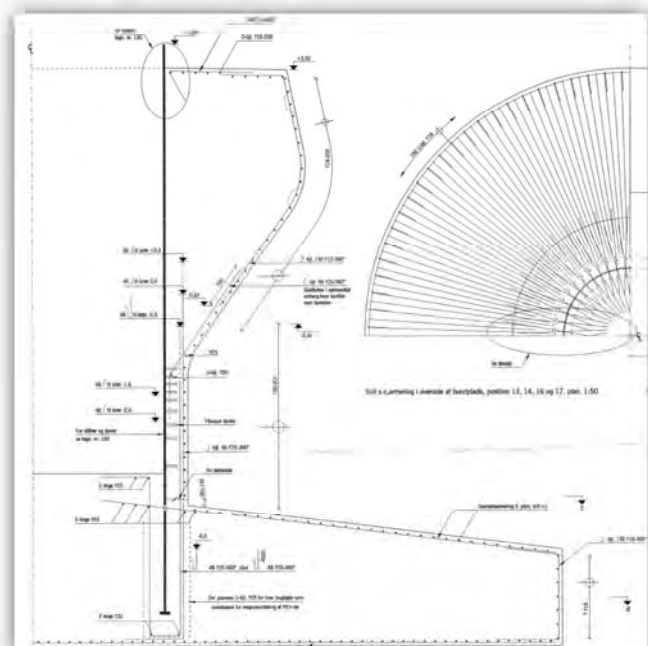


Konstruktionsprincipper

4

Middelgrunden

- Massiv bundplade
- Indstøbt stålør
- Konusplatform
- Særlig afrunding af konus
- Beton som ballast



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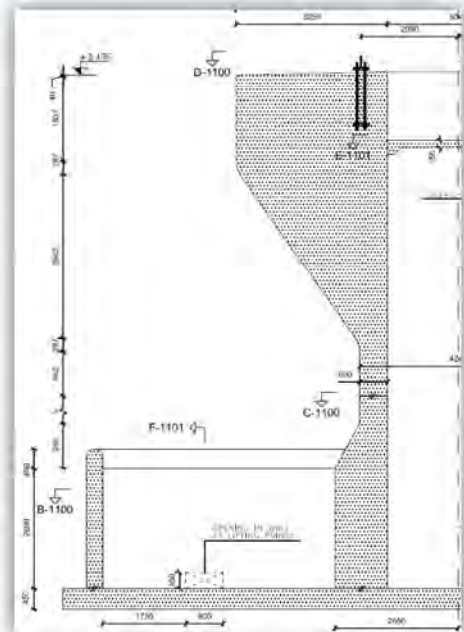
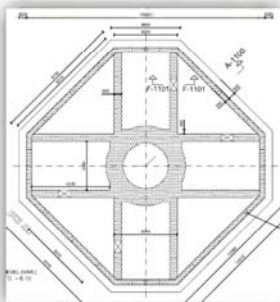


Konstruktionsprincipper

5

Rødsand 2

- Bundplade med 8 kamre
- Konus platform
- Ren betonløsning
- Indstøbt boltegruppe
- Sand og hyperit som ballast

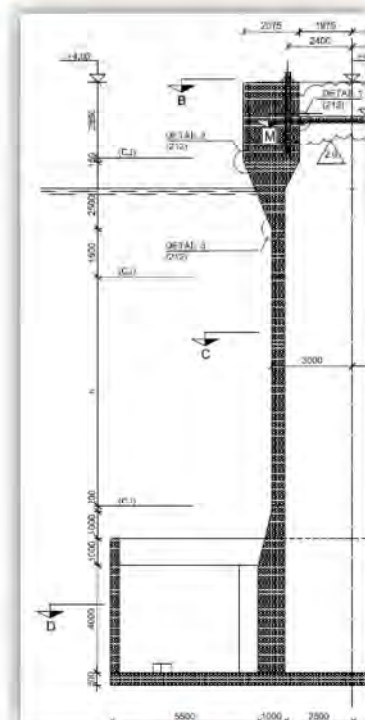
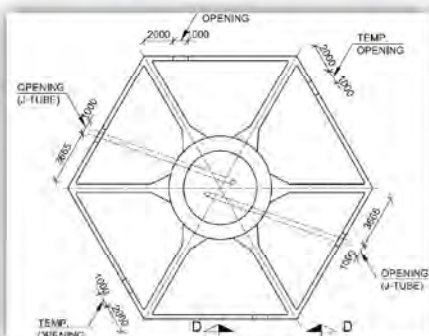


Konstruktionsprincipper

6

Kårehamn

- Bundplade med 6 kamre
- Konus platform
- Ren betonløsning
- Indstøbt boltegruppe
- Magnadense (tung ballast)



Tilsynsplan - Produktion

7

Subject or activity no.	Subject or activity (What is to be checked or inspected?)	Check or inspection method (How is the check or inspection to be carried out?)	Time, frequency or extent (When is the check or inspection to be carried out?)	Criteria of approval	Documentation (How is the check or inspection to be documented?)
Preliminary Works					
00.01	Quality Plan QP01	DR	Before commencement of the foundation production	<ul style="list-style-type: none"> According to Contract VB08-04 Attachment No. 1 and No. 2 DNV-OS-C502 The described inspections are considered to be sufficient for the final quality level. 	Memo with comments
00.02	Concrete mixing plant Concrete laboratory	VI, DR of CEMEX documents	Before commencement of concreting (follow up during concrete works)	<ul style="list-style-type: none"> Factory instructions are fulfilled Equipment is tested and calibrated 	<ul style="list-style-type: none"> Signed approval from CEMEX Memo if nonconformities are detected
00.03	Preparation of barges <ul style="list-style-type: none"> Ballasting Concrete base and geotextiles 	VI, DR of checklist PB	Before start-up onboard the barges (follow up at every return of barges)	<ul style="list-style-type: none"> Ballasting tested and functional cf. checklist PB Concrete base is free of damages and geotextile is placed without folds cf. checklist PB 	<ul style="list-style-type: none"> Signed checklist PB Photos Memo if nonconformities are detected

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Tilsyn med Produktion - Beton

8



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Tilsynsplan - Produktion

9

Subject or activity no.	Subject or activity (What is to be checked or inspected?)	Check or inspection method (How is the check or inspection to be carried out?)	Time, frequency or extent (When is the check or inspection to be carried out?)	Criteria of approval	Documentation (How is the check or inspection to be documented?)
Reinforcement and formworks					
01.01	Quality of delivered reinforcement steel	DR of certificates from DANSTEEL, VI	At delivery (once every month)	DS/EN 10080 Steel for reinforcement of concrete	<ul style="list-style-type: none"> Signed checklist RIR(X) Memo if nonconformities are detected
01.02	Placement of reinforcement bars <ul style="list-style-type: none"> Distribution Lap length/lap distribution Dimensions and bends 	VI, M (measuring stick)	Before concreting of each section bottom slab, shaft and ice cone (first 3 foundations and afterwards every 6 th foundation)	<ul style="list-style-type: none"> According to Drawings DNV-OS-C502, SEC. 7, H100-H124 	<ul style="list-style-type: none"> Signed drawings with remarks Photos Signed checklist IRF(X)
01.03	Concrete cover <ul style="list-style-type: none"> Spacers 	VI, M (measuring stick)	Before concreting of each section bottom slab, shaft and ice cone (first 3 foundations and afterwards every 6 th foundation)	According to General Note drawing no. 69019-DWG-0011	<ul style="list-style-type: none"> Signed drawings with remarks Photos Signed checklist IRF(X)
01.04	Mounting of formwork <ul style="list-style-type: none"> Straightness Stability Proper insulated Concrete cover 	VI, M (measuring stick)	Before concreting of each section bottom slab, shaft and ice cone (first 3 foundations and afterwards every 6 th foundation)	<ul style="list-style-type: none"> According to drawings According to curing control report FC(X) 	<ul style="list-style-type: none"> Signed drawings with remarks Photos Signed checklist FC(X)
01.05	Embedded parts for temperature control <ul style="list-style-type: none"> Cooling pipes Thermal sensors 	VI	Before concreting of each section bottom slab, shaft and ice cone (first 3 foundations and afterwards every 6 th foundation)	<ul style="list-style-type: none"> According to curing control report FC(X) 	<ul style="list-style-type: none"> Signed checklist IRF(X) and FC(X) Photos

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Tilsyn med Produktion - Armering

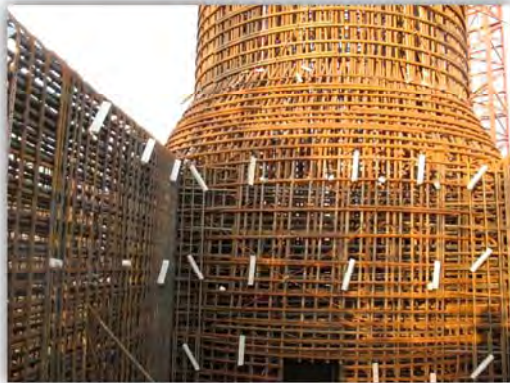
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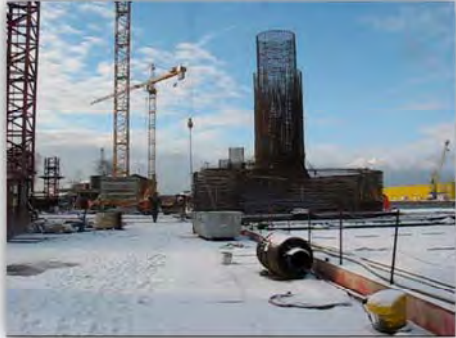


Tilsyn med Produktion - Armering



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Tilsyn med Produktion - Armering



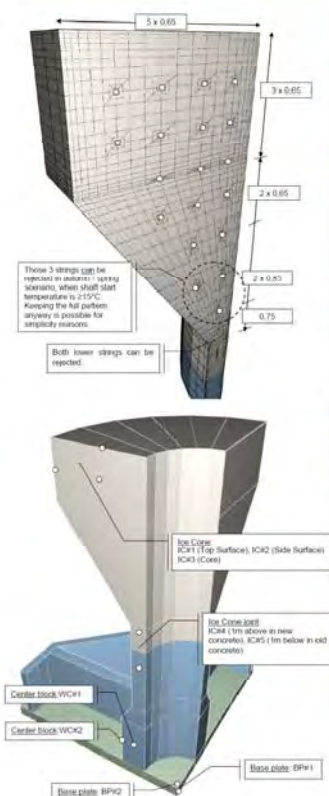
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Tilsynsplan - Produktion

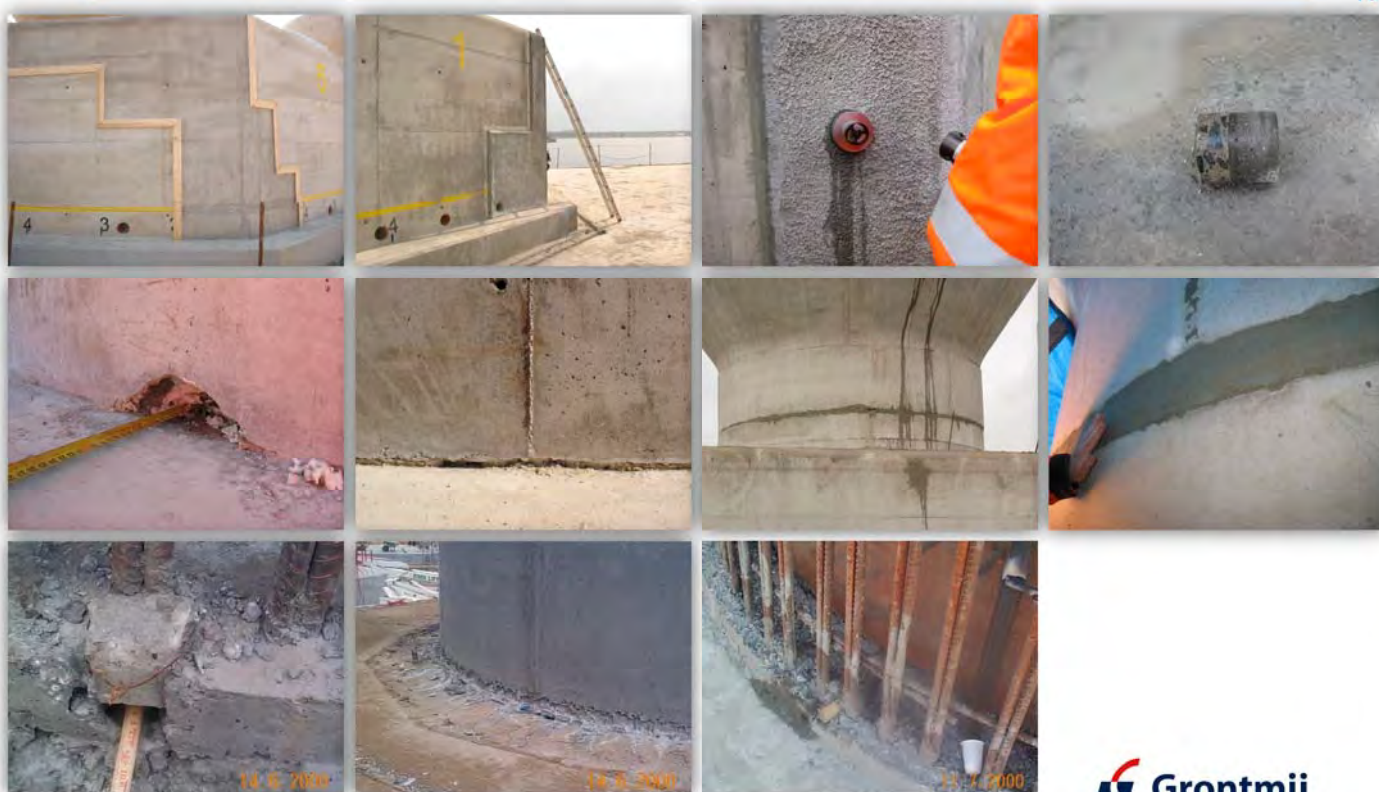
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Concrete casting					
02.01	Concrete composition	DR of concrete mix from CEMEX	In due time before casting (once)	• DNV-OS-C502, SEC 4 • Drawing 69019-DWG-0011	Memo with comments
02.02	Temperature simulations	DR of Report from temperature simulations	In due time before the first casting of each section (once)	• DNV-OS-C502, SEC 7, J306-J308 • Drawing 69019-DWG-0011	Memo with comments
02.03	Quality of concrete • Strength • Density • Frost resistance	DR of laboratory Test report	During the entire casting process (all test reports shall be reviewed)	• DNV-OS-C502, SEC 4 and SEC 7, F400 • Drawing 69019-DWG-0011	• Signed Test Reports • Memo if nonconformities are detected
02.04	Execution of concreting • Vibration/compaction • Continuity (layer thickness) • Ballasting of barges • Curing protection	VI	During concreting of each section bottom slab, shaft and ice cone (first 3 foundations and afterwards every 6 th foundation)	• DNV-OS-C502, SEC 7, J100-J300 • ENV 13670-1, SEC 8	• Memo of inspection • Photos
02.05	Casting joints • Cleanliness • Roughness (use of retarder)	VI	Before casting of next section i.e. bottom slab, shaft or ice cone (first 3 foundations and afterwards every 3 rd foundation)	• DNV-OS-C502, SEC 7, J203 • ENV 13670-1, SEC 8	• Memo of inspection • Photos • Signed checklist IRF(X)
02.06	Concrete cover	M (by use of cover meter)	After removal of formwork (first 2 foundations and afterwards every 12 th foundation)	• Drawing 69019-DWG-0011 • DNV-OS-C502, SEC 6, Q200	• Signed drawing with remarks (test results) • Memo if nonconformities are detected • Signed checklist FC(X)
02.07	Protection during hardening • Temperature measurements • Cooling (if necessary) • Curing compound • Cover mats (if necessary)	VI, DR of Curing Control Report	During the hardening process of each section i.e. bottom slab, shaft and especially the ice cone (inspection of all foundations)	• DNV-OS-C502, SEC 7, J300 • Drawing 69019-DWG-0011 • According to Curing Control report FC(X)	• Signed Curing Control report • Memo if nonconformities are detected • Photos
02.08	Final concrete surface • Inspection of damages • Casting joints • Crack inspections • Honeycombs • Slope for drainage of cone (top) • Overall tolerances	VI, M (crack width, if any, is measured with a simple reference of thickness) DR of survey reports	Before departure from construction site (inspection of all foundations)	• DNV-OS-C502, SEC 7, J400 • According to drawings	• Drawing for each foundation with results of inspections • Photos • Signed survey reports • Signed checklists FC(X) and CC • Memo if nonconformities are detected



Tilsyn med Produktion – Køling og Curing



Tilsyn med Produktion – Dæklag & Støbeskel



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Tilsyn med Produktion – Revner



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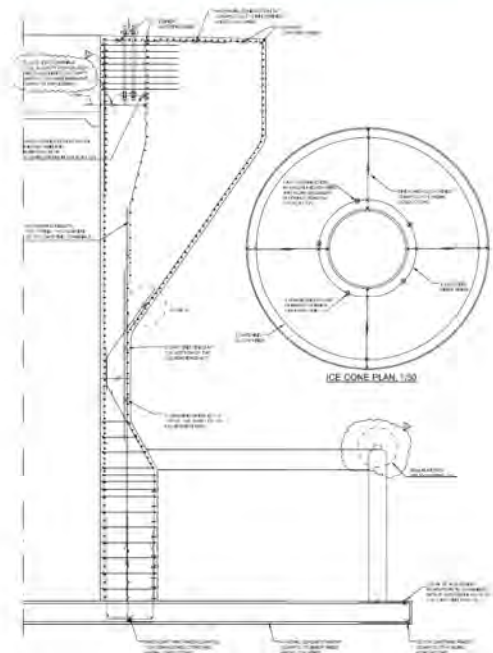


Tilsynsplan - Produktion

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Embedded parts & appurtenances					
03.01	Lightning protection and Corrosion protection (anodes) <ul style="list-style-type: none"> Control of conductivity Clamping of reinforcement Placing of down conductors Anodes 	VI, DR of conductivity report from electrician	Before concreting of each section bottom slab, shaft and ice cone (first 3 foundations and afterwards every 6 th foundation)	<ul style="list-style-type: none"> According to Contract VB08-04 Attachment No. 2, p. 8-9 According to drawings 	<ul style="list-style-type: none"> Signed conductivity report Photos Memo if nonconformities are detected
03.02	J-tubes <ul style="list-style-type: none"> Quality of delivered materials Dimensions and placing Connections (welding) 	VI, DR of material certificates, M (measuring stick)	Before and after concreting of shaft section and after filling with ballast sand (first 3 foundations and afterwards every 6 th foundation)	<ul style="list-style-type: none"> According to Contract VB08-04 Attachment No. 2, p. 7 According to drawings (DWG-401) 	<ul style="list-style-type: none"> Signed checklist ACW Photos Memo if nonconformities are detected
03.03	Anchor ring and Bolts <ul style="list-style-type: none"> Quality of delivered materials Position of bolts Control for damages to bolts 	VI, DR of material certificates, survey report and inspection report DICRB	Before and after concreting of ice cone section (inspection of all foundations)	<ul style="list-style-type: none"> According to drawings Successful control with measuring template 	<ul style="list-style-type: none"> Signed inspection report DICRB Photos Memo if nonconformities are detected
03.04	Cellar deck <ul style="list-style-type: none"> Final mounting Connection with J-tubes 	VI, M (measuring stick)	After mounting of deck (first 3 foundations and afterwards every 6 th foundation)	<ul style="list-style-type: none"> According to Contract VB08-04 Attachment No. 2, p. 8 According to drawings (DWG-401) 	<ul style="list-style-type: none"> Signed checklist ACW Photos Memo if nonconformities are detected
03.05	Railings <ul style="list-style-type: none"> Quality of delivered materials Corrosion protection/surface treatment (damages) Fastening by chemical anchors Electrical earthing 	VI, DR of material certificates, DR of tensile test of chemical anchors, M (thickness of corrosion protection by cover meter)	Before departure from construction site (inspection of all foundations)	<ul style="list-style-type: none"> According to Contract VB08-04 Attachment No. 2, p. 5-6 According to drawings (DWG-201, DWG-202) 	<ul style="list-style-type: none"> Signed checklist ACW Photos Memo if nonconformities are detected
03.06	Access ladders <ul style="list-style-type: none"> Quality of delivered materials Corrosion protection/surface treatment (damages) Fastening by chemical anchors Electrical earthing 	VI, DR of material certificates, DR of tensile test of chemical anchors, M (thickness of corrosion protection by cover meter)	Before departure from construction site (inspection of all foundations)	<ul style="list-style-type: none"> According to Contract VB08-04 Attachment No. 2, p. 6 According to drawings (DWG-301) 	<ul style="list-style-type: none"> Signed checklist ACW Photos Memo if nonconformities are detected
03.07	Bollards <ul style="list-style-type: none"> Quality of delivered materials Corrosion protection/surface treatment (damages) Electrical earthing 	VI, DR of material certificates, M (thickness of corrosion protection by cover meter)	Before departure from construction site (inspection of all foundations)	<ul style="list-style-type: none"> According to drawings (DWG-201) 	<ul style="list-style-type: none"> Signed checklist ACW Photos Memo if nonconformities are detected



Tilsyn med Produktion - Indstøbningsdele



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Tilsyn med Produktion - Indstøbningsdele

19



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Tilsynsplan - Installation

20

0. Indledende arbejder (metodebeskrivelser)
1. Generelle arbejder (kontrol af udstyr)
2. Udgravning for fundamenter
3. Klapping af uddybningsmaterialer
4. Etablering af skærvepuder
5. Placering af fundamenter
6. Ballastering af fundamenter
7. Installation af kabelrør (flex pipes)
8. Placering af scour beskyttelse
9. Kontrol af udstyr på fundamenter (rækværk, pullerter og stige)
10. Afleveringsforretning (inspektion)

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Tilsynsplan – Installation - Skærvepuder

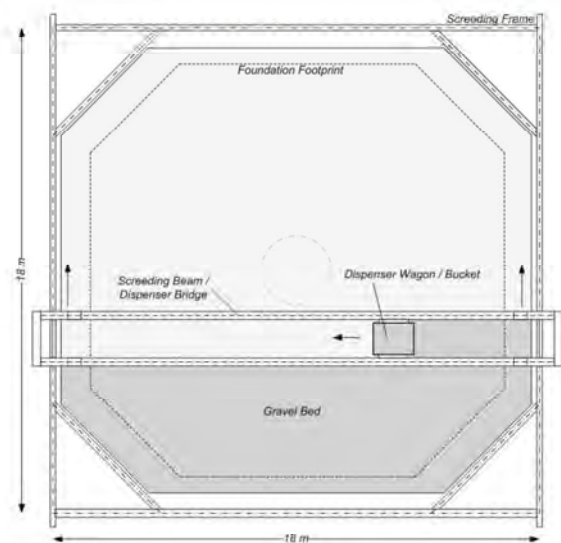
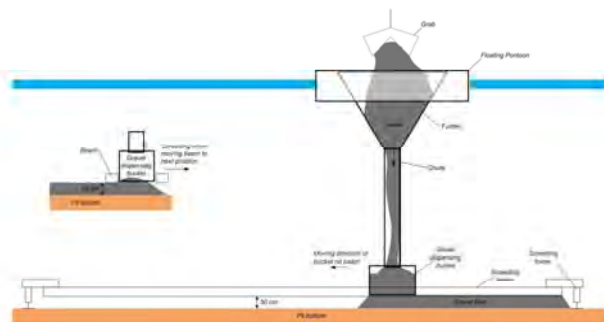
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04 Placing of gravel bed					
04.01	Check PDS 2000 survey system	DR, Coordination with 'E.ON surveyor'	Before departure port, all	Acceptable deviations	Signed checklist QP 03-I
04.02	Check position Jack-Up	DR, VI, Coordination with 'E.ON surveyor'	Before placing of frame All documents Inspections 2-5 positions	Done	Signed checklist QP 03-II
04.03	Check position screeding frame	DR, VI	Before cleaning / built-in of gravel bed Inspections 10-20 positions	Tolerance	Signed checklist QP 03-III Signed checklist QP 03-IV
04.04	Filter layer 1 (only sand bottom)	DR, Video review	All positions Before installation of foundation	<ul style="list-style-type: none"> Measure plan Tolerances 	Signed checklist QP 03-V Video Memo Possibly measure plan from ABJV
04.05	Cleaning of pit bottom ("vacuum cleaner")	DR, Video review	All documents and videos Inspections 5-10 positions Before installation of foundation	Clean bottom	Signed checklist QP 03-V Video Memo
04.06	Gravel bed layer – levelling (Evening with beam on frame)	DR, Video review	All documents and videos Inspections 5-10 positions Before installation of foundation	<ul style="list-style-type: none"> Measure plan +/- 30mm 	Signed checklist QP 03-V Video Memo
04.07	Recess	DR, Video review to be made together with inspections of the gravel bed	All documents and videos Inspections 5-10 positions Before installation of foundation	According to Design Brief Sec. 5.4	Any documentation
04.08	Cleaning of gravel bed	DR, Video review	All documents and videos Just before placing foundation	Clean surface	Comment checklist QP 03-V Video Memo
04.09	Video after cleaning gravel bed	DR, Video review	All cleaned gravel beds	<ul style="list-style-type: none"> Clean surface +/- 30mm 	Comment checklist QP 03-V Video / Memo



Tilsyn med Installation - Skærvepuder

22



Tilsyn med Installation - Skærvepuder

23

RODSAND 2 Check List QP03-II Installation of Gravel Bed

Project: Rodsand 2 Offshore Wind Farm Project no: 130950

Quality Control Item: _____ Date: _____ Related Docs: _____

Foundation: _____

Positioning of frame

a. Frame placed (guided by crane survey system & as described in QP03-7.3.3.) Due

Height Reference System

b. Diver inspection of seabed prior placing height reference masts (no obstructions, seabed flat) Due

c. Static measurement performed on mast 1 (yellow) & 2 (white) Due

d. Settlement of height reference mast Yes No Due

e. Reference pressure transducer set to reference height (mast2) Yes No Due

f. Check of pressure transducer system, System okay Yes No Due

Cleaning of pd

g. Gravel bed area cleaned (excavator, A104) Yes No Due

h. Additional cleaning necessary (according to diver inspection) Yes No Due

Additional cleaning performed by: Excavator Suction

i. Knife test performed. Seabed ready for gravel bed. Yes No Due

Gravel Bed

j. Levelling of frame Frame Target level: _____ m Due

k. Screeding Due

l. Check level of frame. Level (incl. deviations) okay? Hydraulic Jack No. 3 4 5 6 7 8 Yes No Due

m. Check of evenness of gravel bed. Tolerance not exceeded (check on 25 points; tolerance: +0 / -3cm) Yes No Due

n. Center hole created (diameter 2.35 - 2.85) Yes No Due

o. Position of frame checked Yes No Due

Comments: _____

Enclosures: No 1 Level calculation for reference blocks
No 2 Check list "Knife Test"
No 3 Check list "Quality Check of Gravel Bed"

ABJV site engineer: _____ MRBM:IST _____

RODSAND 2 Quality Check of Gravel Bed

Location: _____ Date: _____

Evenness Check: _____
Frame Level Check: _____
Center Hole: _____
Position Check: _____

Legend:

- ✓ Evenness in tolerance
- Evenness NOT in tolerance → note exceedance in ± [mm]
- Final frame level (note reading of pressure cell monitor)
- ✓ Center hole created and checked (min Ø 2.35 m, max Ø 2.85 m)
- ⚠ Position of leg checked and okay; if position is out by more than 10 cm (in any direction) please proceed to extra check list: 'Position of Gravel Bed'

Comments: _____

Signature (Foreman / Engineer): _____



Tilsynsplan – Installation - Fundamentsplacering

24

Subject or activity no.	Subject or activity (What is to be checked or inspected?)	Check or inspection method (How is the check or inspection to be carried out?)	Time, frequency or extent (When is the check or inspection to be carried out?)	Criteria of approval	Documentation (How is the check or inspection to be documented?)
05 Placing of foundation					
05.01	Prepare departure from Poland - Information E.ON WVC - Weather forecast - Maritime Warranty Surveyor	Notice 4 days in advance 24h window for transport Tug certificate	All foundations	Wave max. 2.5m Sea fastening and MVS certificates	Report with comments from MVS Checklist IP07 in QP04 Tug certificate (MVS)
05.02	Check survey system	Coordination with "E.ON surveyor"	Before departure port, all	Acceptable deviations	Signed checklist QP04
05.03	Check weather forecast for suitable weather 24h "window" for each foundation	DMI weather forecast together with WVC	All foundations 24h before installation	Sig. wave height below 0,75m; wind below 10 m/s	Weather forecast Checklist QP04
05.04	Check gravel bed surface before placing	Video review (10-20%) Checklist QP04	All foundations	Surface within tolerances +/- 30mm and clean No damages to the gravel bed	Diver inspection report
05.05	Supervision when lowering	VI	All foundations when lowering	ABJV survey according to tolerances Position: +/- 300mm Height: +/- 100mm Heading: +/- 2° Inclination: +/- 0,25° relative to horizontal plane	Checklist QP04 Memo Comments from Marine Warranty Surveyor, MWS
05.06	Inspection of placed foundation	Video review	All documents and videos	To assure no gabs underneath foundation caisson	Video Memo



Tilsyn med Installation - Placering



Tilsyn med Installation - Placering

RØDSAND 2 INSPECTION REPORT Inspektionsrapport

Inspection of Gravelbed / Placed Foundation

Location: _____ Date: _____ Dive No. (Mts A): _____

Start point of inspection: _____ Wall no.: _____ Inspection direction: _____

Checkliste: / Countercheckliste:

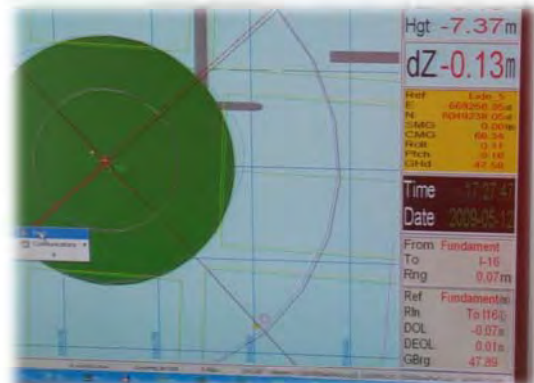
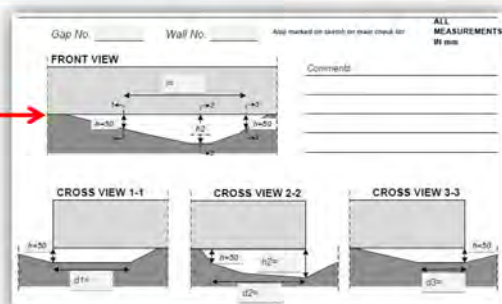
WESTERN FLEXPipe: _____ EASTERN FLEXPipe: _____

Inspection instructions:

- Gaps in gravel bed below foundation (mark on sketch and state if action required):
 - Gaps less than 50mm: No action
 - Gaps between 50mm – 100mm: Fill in gravel material
 - Gaps above 100mm: Call the engineer on duty
- Concrete damage (mark on sketch, note dimensions (area, depth))
- Other faults to foundation (mark on sketch, describe/comment below)

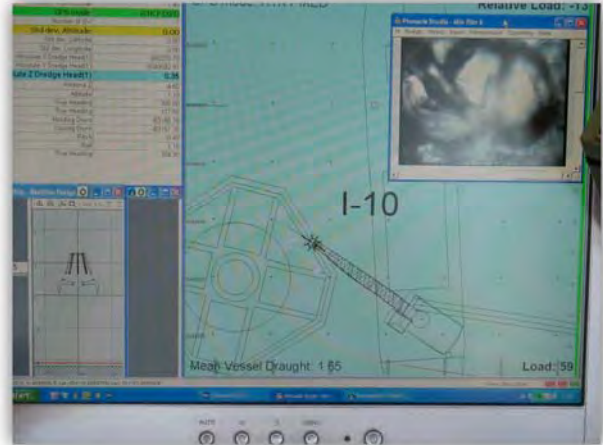
Comments: _____

Signature (Foreman / Engineer): _____



Tilsynsplan – Installation - Ballastering

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06 Placing of ballast					
06.01	Check PDS 2000 survey system	DR, Coordination with "E.ON surveyor"	Before departure port, all	Acceptable deviations	Signed checklist QP 02-I
06.02	Check of position and quantities	DR As-built doc. • Diver video inspection • PDS 2000 measure plan	All positions After placing ballast	Tolerances	Signed checklist QP 02-VII Video Memo



Tilsyn med Installation - Ballastering



Eventuelle spørgsmål



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