International guideline on the risk management of offshore wind farms

Offshore Code of Practice

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List of companies involved in the risk analysis

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Preface

The European Wind Turbine Committee (EWTC) composed of European direct-writing insurers and reinsurers launched the initiative "Offshore Code of Practice" in 2010. The German insurance association GDV (Gesamtverband der Deutschen Versicherungswirtschaft e. V.) and the foundation Offshore Windenergie are supporters of this initiative. In spring/summer 2014 the GDV publishes the document Offshore Code of Practice (OCoP) named after this initiative for the first time. This is planned to be reviewed and edited regularly and upon important changes in technology and risk management processes to be up-to-date.

Motives for the OCoP have been that

- offshore wind farm projects are vast and complex,
- the experiences gained so far in the installation of offshore wind farms in specific areas, such as deep waters of the North Sea, are limited,
- this is a young business striving for immense growth.

The erection of offshore wind farms involves a multitude of the most different risks that should be dealt with proactively. Early detection allows reduction or prevention of such risks.

This initiative aims at establishment of a guideline dealing with the risk management for the erection of offshore wind farms. This guideline shall point out significant risks as well as the importance of a complementary risk management. Furthermore, the OCoP shall motivate any actor involved in the erection to implement risk management procedures.

A transparency of risks resulting therefrom can reduce the risk of damage and provide for long-term insurability of offshore wind farm projects. The OCoP shall represent the risks and proven methods of erection of offshore wind farms. However, as the possible designs of offshore wind farms are manifold it is neither reasonable nor possible to give general recommendations.

The risks and protection measures stated in the OCoP are intended to be an appropriate guidance in practice. The OCoP is not exhaustive. It should only point out the most important issues of the risk management for an installation of offshore wind farms.

The risk analysis made in the work groups is fundamental to the OCoP. This is the definition and assessment of risks and relevant protection measures for any important operation. The risk analysis shall cover the risks which can cause significant damage to deliveries and services, project delays due to property damage, as well as losses due to business interruption during the installation of an offshore wind farm. The knowledge documented in the lists of risks is based on the experiences of the experts involved. To ensure uniform structure, all participants got instructions on how to proceed. The work groups have been composed of experts in the offshore business proving knowledge in different fields. These have been representatives of

- direct-writing insurers and reinsurers, insurance brokers;
- manufacturers, operating parties, developing companies;
- investors, banks, consultants, certifiers, utility companies;
- shipping companies, technical experts, Marine Warranty Surveyors (MWS);
- as well as of the German insurance association GDV (Gesamtverband der Deutschen Versicherungswirtschaft e. V.) and the foundation **Offshore Windenergie**.

This is the opportunity to thank anyone involved in the development of the OCoP for his/her cooperation and commitment!

1 Introduction

1.1 Purpose

The guideline aims at pointing out how important the implementation of risk management procedures is. On the one hand, risk management procedures involve early detection of potential risks during the erection of offshore wind farms. On the other hand, they involve protection measures taken as a prevention to reduce or even prevent such risks. This should minimise the risk of damage to property and loss by delay or at least reduce this to an acceptable level and optimise security of supply.

Target groups of the OCoP are the risk bearers in the insurance business as well as any actor involved in the erection of offshore wind farms.

Use of and compliance with the present guideline is at your discretion.

Purpose of the OCoP is that the target groups will comprehend the processes taking place, potential risks, and possible protection measures to reduce or prevent risks or that they become sensitive to these. Thus, the guideline points out to primary risks and the target groups can use it as a reference work.

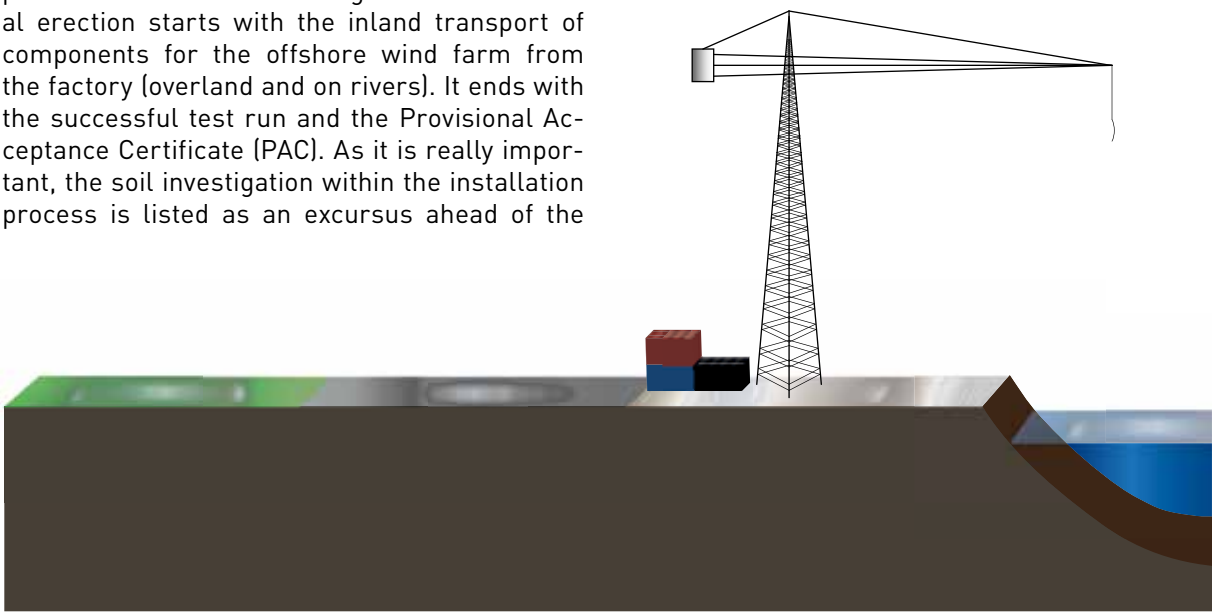
1.2 Scope

The scope of the OCoP is the erection of an offshore wind farm and the risk management procedures involved. In the guideline the actual erection starts with the inland transport of components for the offshore wind farm from the factory (overland and on rivers). It ends with the successful test run and the Provisional Acceptance Certificate (PAC). As it is really important, the soil investigation within the installation process is listed as an excursus ahead of the inland transport. Figure 1 shows the different process steps including main fields of activities being part of the erection.

The erection considered in the OCoP refers to the trades of cabling in wind farms, offshore transformer station in wind farms, and offshore wind turbine.

The guideline does not cover the design and development work, the manufacture of work items, and the operating stage following the installation. It should nevertheless be pointed out that any

Figure 1: Erection including the fields of activities



Erection

Soil investigation	Inland transport	On-shore assembly and storage	Offshore transport
• Geophysical investigations • Geotechnical preliminary exploration • Geophysical final analysis (in consideration of the results of the geotechnical preliminary exploration) • Geotechnical main investigations • (...)	• Loading • Inland transport (rivers and overland) • Transshipment • Intermediate storage • Unloading • (...)	• Identification of port/ port requirements • Storage in offshore port • Onshore assembly in offshore port • Acceptance of onshore assembly • Shipment to the quay edge (port transport) • Preparations for offshore transport (packaging, tests, etc.) • (...)	• Port cargo handling • Stowing • Sea-fastening • Offshore transport • Dynamic positioning, dropping of anchor, etc. • Approval by MWS • (...)

MWS: Marine Warranty Surveyor; OWT: Offshore Wind Turbine; OTS: Offshore Transformer Station; OWF: Offshore Wind Farm

knowledge as to the design, manufacture, and operation resulting from the risk analysis shall be taken into consideration.

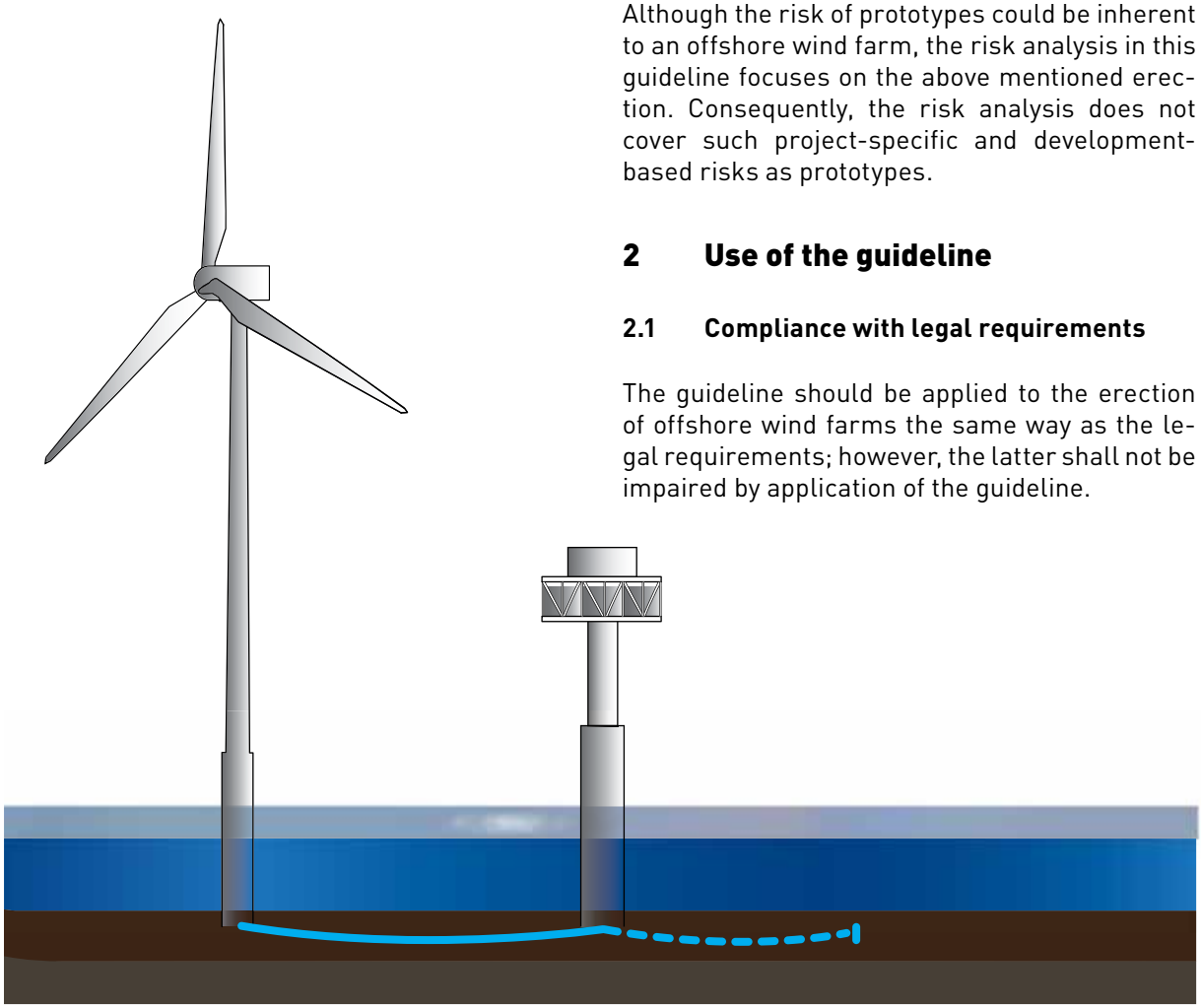
Purchase and the delivery of offshore wind farm components from places beyond Europe are not examined either.

Although the risk of prototypes could be inherent to an offshore wind farm, the risk analysis in this guideline focuses on the above mentioned erection. Consequently, the risk analysis does not cover such project-specific and development-based risks as prototypes.

2 Use of the guideline

2.1 Compliance with legal requirements

The guideline should be applied to the erection of offshore wind farms the same way as the legal requirements; however, the latter shall not be impaired by application of the guideline.



Erection | **Betrieb**

Offshore erection	Residual assembly work offshore	Commissioning and test run
• Pre-/post-piling of footing structure • Grouting • Lifting and lowering • Arresting • Installation of the cable in the wind farm • Pulling in of the cable in the wind farm and the sea cable • Approval by MWS • (...)	• Provision of the external power supply • Connection of the cable in the wind farm and of the sea cable • Approval by MWS • (...)	• Tests • Mains connection of the OWT to the OTS • Mains connection to the OTS of the transmission grid operator • Function tests • Approval • Approval by MWS • Test runs of OWF • (...)

2.2 Structure of the guideline

The guideline informs about the erection of offshore wind farms examined in the OCoP (see Chapter 1), the risk management in general (see Chapter 3), and the potential tasks and fields of responsibilities of the MWS (see Chapter 4). However, the main emphasis is on the significant potential risks that could occur during erection of the trades: cabling in wind farms, offshore transformer station in wind farms, and offshore wind turbines in an offshore wind farm (see Chapter 5). The significant risks are integral part of the knowledge resulting from the lists of risks drawn up to this end in the work groups. This means that the knowledge and the experiences of the more than 90 experts working in the offshore business found their way into the results.

The guideline delivers descriptions of operations for each process step defined for the trades of cabling in wind farms, offshore transformer station in wind farms, and offshore wind turbine. Moreover, it describes the hazards and protection measures for each operation and gives a general assessment. The risk assessment has been provided without and in consideration of the effects of a protection measure.

The risks have been assessed to fit in one of the four categories below, which reflect the potential risk:

- low risk,
- medium risk,
- high risk,
- very high risk.

Each risk listed for an operation is followed by an assessment of the extent of property damage and loss due to delay as well as of the probability of occurrence. As to the property damage and losses due to delay, the potential financial loss has been estimated.

The protection measures have been assessed to fit in one of the three categories below:

- very good,
- adequate,
- poor.

They inform on the potential effect of a protection measure.

The effect of a protection measure is very good if the risk resulting from a hazard (damage to property / loss due to delay) can almost be excluded as far as our experience goes. Thus, the protection measure provides for control of the risk.

The effect of a protection measure is adequate if taking the measure noticeably reduces the risk resulting from a hazard (damage to property / loss due to delay) as far as our experience goes. The protection measures noticeably cut down the risk.

The effect of a protection measure is poor if taking the measure hardly reduces the risk resulting from a hazard (damage to property / loss due to delay) or does not reduce it at all as far as our experience goes. Although a protection measure has been taken and met, the risk endures.

Based on the assessments of the risk and the protection measures, the risk is again classified in the four risk categories above. This underlines significant risks involved in an operation or process step. A risk is significant if the potential risk of the corresponding hazard connected to an operation is high to very high despite considering and taking of the protection measures. A precise description of how to proceed in risk analysis is given in the annex of the guideline (see Chapter 8.4). In addition, the lists of risks are enclosed with this document as an annex. As the information given in the lists of risks is not complete we ask for a sensitive use of this knowledge and the corresponding data. The examples given there shall only help you to orient yourself.

Selection of the operations, hazards, and protection measures included in the lists of risks as well as the risk assessments and the effects of the protection measures were effected in the work groups. Please mind that the assessments are estimates. To define the "correct" assessment has made greatest demands on the work groups. The estimates are based on experiences, which have been gained in particular fields and, consequently, are subject to uncertainty. This could be compensated for by a wide choice of experts and interdisciplinary work groups. Moreover, only those hazards have been included that could be considered involving a risk at the very moment of the risk analysis. Thus, the participants narrowed down the choice.

We additionally point out that the risk analysis in the work groups were made on conditions, which have to be connected to the results and taken into account. This means that the data may vary in a user-project as the general set-up differs. Thus, you may have to adapt the data to the project.

3 Introduction to risk management

3.1 Process of risk management

The risk management is part of the project management and can be described as a systematic and continuous process of identification, analysis, assessment, and treatment of risks. An early implementation of protection measures to delimit the risk optimises the process. The risk management procedure can generally be subdivided into the following activities:

a) establishing a context, in which the basic parameters, criteria, influencing variables, system limits, and objectives are defined;

b) assessing the risks by identifying, analysing, and appraising the hazards and the risks involved;

c) planning and taking proactive protection measures to prevent or reduce the risks;

d) implementing control mechanisms to continuously monitor and study the risk;

e) developing strong communication and documentation structures between the actors involved to link the different fields of knowledge and carefully consider the different interests and views;

f) assigning responsibilities in the risk management procedure to the actors involved so that the fields of responsibility are clearly defined regarding a reduction and prevention of risks.[1]

Activity b) through d) of the risk management procedure are iterative, one based upon another and with mutual effect. Activities e) and f) take place parallel to the other activities.

The risk assessment forms integral part of the risk management procedure as this delivers understanding of hazards, their causes, their consequences, their probabilities of occurence, and their extent of damage as well as the necessity to take protection measures.

This is subdivided into the three stages below, which take place in succession:[2]

- Risk identification
- Risk analysis
- Risk assessment (see Chapter 8.1)

Here, we would like to point out that the risk management procedure should be seen as continuous cyclical improvement process. It shall be repeated again and again to curtail potential risks to an acceptable level on the one hand and to take into account any project changes resulting in the course of time on the other hand.

Literature gives many possible definitions of a risk. The general risk definition (see Chapter 8.1) means for the OCoP that the risks occurring within the scope of erection of an offshore wind farm are (property) damage to all deliveries and services of relevance to the erection itself and delivered (onshore and offshore) as well as any project delays due to such damage.

Damage means any damage to or destruction of an object (property damage) whereas project delay means any delay in the (final) completion that is due to a compensable property damage (loss resulting from a delayed commissioning) of the offshore wind farm.

3.2 Risk assessment techniques

Risk assessment techniques should be applied to all life cycle steps of offshore wind farms, thus, to the erection, too. Each actor involved in the erection of offshore wind farms should be responsible for a realisation of risk assessment in his/her field of activities.[3]

There is a multitude of risk assessment techniques differing in the level of details and method (scope of examinations, number and complexity of the selected procedures, etc.) in the corresponding stage and/or field of and requirements for the system or the object under examination.

1 Risk management -- Risk assessment techniques (IEC/ ISO 31010:2009); German version EN 31010:2010, Page 7 et seq.

2 Risk management -- Risk assessment techniques (IEC/ ISO 31010:2009); German version EN 31010:2010, Page 9

3 Risk management -- Risk assessment techniques (IEC/ ISO 31010:2009); German version EN 31010:2010, Page 15

Some risk assessment techniques, for instance, only refer to the mere identification of risks whereas other ones cover identification, assessment, evaluation and point out additional protection measures to minimise or prevent the risks. Each person responsible should define the scope of examination with due consideration of the overall risk management as to the continuous cyclical improvement process.[4]

The guideline uses a simple list of risks as risk assessment technique. This gives a first survey of the process steps of erection and the risks involved. The list of risk is based on the risk analysis and, therefore, contains the process steps and operations examined in the OCoP, the determination of hazards, and the deduction of protection measures, as well as an assessment of the risks without and with protection measures.

3.3 Documentation, verification, and monitoring of risks

The different steps of the selected risk assessment technique should be adequately documented. To this end, you can draw up different lists, which show the main steps of the technique and determine and assign the responsibility for the risk. The lists should describe at least the hazards and risks of each operation as well as the protection measures required to reduce or prevent such risks. Moreover, they should provide for transparency and comprehensibility regarding the assessments and evaluations of risks and protection measures.

It shall be pointed out, as well, that the deeper the information on hazards, risks, and protection measures are, the less free the user of the lists is to interpret.[5]

In addition to the lists for risk assessment, measures to be taken for orientation and to remind of, establish, and verify the required protection measures should be listed, too. These could e.g. name the persons responsible and state the date of completion, the measures, and the hazards if any.

The documents created for the risk assessment technique should "live". This means that they are subject to regular reviews and - in case of changes in the project (facilities, work equipment, transport means, etc.) and, thus, in the risk assessment - to revision. The documents should be available at any time to ensure transparency regarding the risks and the corresponding measures for prevention and reduction taken during the erection of offshore wind farms.

The systems implemented for risk monitoring (e.g. determination of characteristics of considerable potential influence on the risk assessment and monitoring of them) should be implemented in all stages of erection to record any future context, change, etc.[6]

4 Marine Warranty Surveyor (MWS): Possible tasks and responsibilities

For the (erection) insurance of an offshore wind farm, hiring of an MWS as independent third party makes sense. The main job of an MWS is to ensure that the safety guidelines and goals are observed as well as to verify compliance with the procedures agreed upon in the Scope of Work. The MWS shall in particular verify the relevant use parameters (e.g. wind speed, wave height, etc.) with regard to the duration of operation (AdÜ) and the "weather slot".

The MWS makes a big contribution to the implementation of safe procedures during transport and installation of wind farm components and to their insurability. This way, s/he contributes to successful completion of projects.

The insurer and/or the insurance companies involved in the erection of offshore wind farms may propose several MWS to supervise the process. The insured should hire a competent MWS. The insurer and/or the insured should exercise due care when selecting the MWS. The MWS, above all, should prove long-time experience and adequate expertise.

The hired MWS and the loss expert charged upon a damage or loss should not be the same.[7]

If an MWS is hired, the scope of work as defined in the policy shall apply. If required, this can be defined in the kick-off meeting with all parties

4 Risk management -- Risk assessment techniques (IEC/ISO 31010:2009); German version EN 31010:2010, Page 16

5 Risk management -- Risk assessment techniques (IEC/ISO 31010:2009); German version EN 31010:2010, Page 14 et seq.

6 Risk management -- Risk assessment techniques (IEC/ISO 31010:2009); German version EN 31010:2010, Page 15

7 Renewable energies -- Overall survey of Engineering Insurers within the German Insurance Association (GDV) on the level of technological development and the technical hazard potential, Page 117

Table 1: Distribution of the potential risks of the operations required to install the cables in the wind farm examined in the OCoP (WITHOUT and IN consideration of protection measures)

Potential risks	Potential risks of the examined operations w/o consideration of protection measures		Potential risks of the examined operations in consideration of protection measures	
	[number]	[percent]	[number]	[percent]
low risk	5	15	15	35
medium risk	5	15	13	30
high risk	10	29	5	12
very high risk	14	41	1	2

involved (leading insurance company, the insured, and the MWS). Should the project change fundamentally, the scope of activities shall be reviewed and adapted adequately. The MWS should accompany the erection of an offshore wind farm just from the beginning and be involved in the corresponding project meetings of the builders early.[8]

In addition to the above stated main task of the MWS, there are other activities that refer to surveillance and verification of the procedures during marine transport and installation.

These activities can be subdivided in the desktop analysis and the on-site inspection. In the desktop analysis, the documents, plans, calculations, etc. shall be looked through and reviewed. These documents contain among other things an analysis of the site conditions (e.g. ambient and soil conditions), job descriptions, as well as information on shipping, sea-fastening, transport, any installation procedure, and installation of undersea cables.

Furthermore, the MWS shall review whether the means for transport and installation as well as other equipment required for erection meet the technical requirements and prove corresponding approvals for the works they are intended for. During the on-site inspection, the MWS checks how the works have been put into practice and whether they correspond to the already approved plans resulting from the desktop analysis. This affects the ships and equipment used as well as the cargo handling, stowing, fastening of the shipment on the transport means, the transport itself, raising and setting upright the transported offshore wind farm components, the transformer station, as well as undersea cable assembly and laying. Upon completion of the corresponding works and having inspected them, the MWS signs the inspection certificates with a list of his/her activities and findings.[9]

If the parties involved have agreed upon hiring of MWS, normally the insurance is subject to the MWS approval of operations, equipment, etc. If the MWS does not approve an operation, an equipment, etc., s/he gives the insured recommendations how to get the approval / acceptance certificate.

The insured should implement the recommendations of the MWS to prevent withdrawal of insurance coverage for the corresponding activity. The recommendations and/or those implemented are noted down on an approval certificate and handed out to the insurer upon request.[10]

The entrusted MWS shall grant final approval of the activities. Starting of the work before having get this final approval may be a violation of the insurance contract; this depends on the actual wording. In such a case the insured shall bear the risk from this very moment. Should both, the insurer and the insured, have hired an MWS, it is recommendable - as experience has shown - to stipulate with binding force and in advance, the approval or refusal of whom shall be considered for which procedures.[11]

8 Renewable energies -- Overall survey of Engineering Insurers within the German Insurance Association (GDV) on the level of technological development and the technical hazard potential, Page 117

9 Marine Warranty Surveying, Page 25 et seq.

10 Renewable energies -- Overall survey of Engineering Insurers within the German Insurance Association (GDV) on the level of technological development and the technical hazard potential, Page 118

11 Renewable energies -- Overall survey of Engineering Insurers within the German Insurance Association (GDV) on the level of technological development and the technical hazard potential, Page 117

5 Representation of significant risks when building offshore wind farms

Please find in the paragraphs below the process steps of erection defined in the OCoP for the trades of cabling in wind farms, offshore transformer station in wind farms, and offshore wind turbine

Moreover, the significant risks remaining even after taking protection measures are stated for the corresponding process steps. The significant risks are based on the results of the risk analysis.

5.1 Cabling in wind farms

5.1.1 List of process steps under review

The cabling in wind farms considered in the OCoP is composed of the process steps below:

a) execution planning of the soil investigation for the installation of cables in the wind farm;

b) soil investigation for the installation of cables in the wind farm;

c) execution planning of the transport (inland and offshore transport) and of the installation of the cables in the wind farm;

d) execution planning of the connection of the cables in the wind farm;

e) execution planning of the commissioning and the test run until getting the PAC;

f) transport (inland and offshore transport) and of the installation of the cables in the wind farm;

g) connections (installation) of the cables in the wind farm;

h) commissioning and test run until getting the PAC.

5.1.2 Representation of significant risks when installing the cables in wind farms

There have been 34 risks identified and assessed throughout the installation process of cables in the wind farm. Most of them (about 70 %) are of high up to very high potential risk without consideration of protection measures, which can reduce or prevent the risks. The implementation of several protection measures mitigates the hazards of high to very high potential risk by about 56 %. Table 1 overviews the distribution of the potential risk in and without consideration of the protection measures.

The hazards showing a high to very high potential risk despite any protection measures are described below in detail with regard to the process steps. These are process step c) and process step f) because the other process steps have not shown any significant risks during installation of the cables in the wind farm.

Process step c):
Execution planning of the transport (inland and offshore transport) and of the installation of the cables in the wind farm

A high potential risk involves the resource planning, i.e. resources are unsuitable or not available at all. For instance, the personnel has not gained sufficient experience so far, the technical requirements for the ships and the installation equipment do not correspond to the task and the sea area (weather, soil, etc.).

The selection of the equipment for laying of cables involves a high potential risk; i.e. the selected equipment is unsuitable to the laying work.

The execution planning of laying work involves a high potential risk; i.e. alternative plans for possible interruptions of laying are not developed. Interruptions could occur, e.g. by short-term changes in weather, natural hazards, etc.

Process step c):
Transport (inland and offshore transport) and of the installation of the cables in the wind farm

Laying the cables in the offshore wind farm involves a high potential risk. During this process step, above all damage to the cable and equipment are possible.

Trenching and laying the cables in the wind warm into the soil involves a high potential risk; i.e. the trench depth and/or the thickness of the soil covering the cable is insufficient.

Ploughing of the cables in the wind farm involves a high potential risk; i.e. this method can cause damage to the cable.

Table 2: Distribution of the potential risks of the operations required to build the offshore transformer station examined in the OCoP (WITHOUT and IN consideration of protection measures)

Potential risks	Potential risks of the examined operations w/o consideration of protection measures		Potential risks of the examined operations in consideration of protection measures	
	[number]	[percent]	[number]	[percent]
low risk	6	3	103	54
medium risk	32	17	74	39
high risk	100	53	13	7
very high risk	52	27	0	0

5.2 Offshore transformer stations in wind farms

5.2.1 List of process steps under review

The building of the offshore transformer station in wind farms considered in the OCoP is composed of the process steps below:

a) execution planning of the soil investigation for the site of the offshore transformer station in the wind farm;

a) soil investigation for the site of the offshore transformer station in the wind farm;

c) execution planning of the inland transport (overland and rivers) from the factory to the offshore port;

d) execution planning of the storage in the offshore port and the onshore assembly there;

e) execution planning of offshore transports;

f) execution planning of offshore erection;

g) execution planning of residual assembly work offshore;

h) execution planning of the commissioning and the test run until getting the PAC;

i) inland transport (overland and rivers) from the factory to the offshore port;

j) storage in the offshore port and the onshore assembly there;

k) offshore transports;

l) offshore erection;

m) residual assembly work offshore;

n) commissioning and test run until getting the PAC.

5.2.2 Representation of significant risks when building the offshore transformer stations in wind farms

There have been 190 risks identified and assessed throughout the installation process of the offshore transformer station in the wind farm. Most of them (about 80 %) are of high up to very high potential risk without consideration of protection measures, which can reduce or prevent the risks.

The implementation of several protection measures mitigates the hazards of high to very high potential risk by about 73 %. Table 2 overviews the distribution of the potential risk in and without consideration of the protection measures.

The hazards showing a high to very high potential risk despite any protection measures are described below in detail with regard to the process steps. These are process step b), process step j), process step k), process step l), and process step n). The other process steps required to build the offshore transformer station in the wind farm do not involve any significant risks.

Process step b):
Soil investigation for the site of the offshore transformer station in the wind farm

A high potential risk occurs in case the actual soil conditions significantly deviate from the geological, geophysical, and geotechnical investigation results. The consequences are as follows:

- insufficient stability of the installation points of the offshore transformer station in the wind farm;

- feasibility of driving and footing (piling) due to the conditions of the sea ground is not ensured;
- insufficient levelling due to variations in the thickness of bearing beds (ruggedness);
- search for ammunition (not considered separately in the OCoP);
- objects and/or obstacles at the pile positions (e.g. wrecks, undersea cable, etc.).

These potential hazards can cause different adverse effects on the erection of the offshore wind turbines; e.g.

- an installation of the offshore transformer station of the wind farm at the planned position is impossible so that the position has to be turned down;
- the ram piles cannot be rammed down to the planned depth;
- the ram piles can be subject to deformation;
- the ramming equipment can be damaged;
- the ram piles are unsuitable for the soil;
- the ram piles become stuck in the sea ground during ramming because they are blocked by objects;
- yet not discovered ammunition is found in the ramming area, so that explosion can cause damage to or loss of piles, installation work equipment, and transport means as well as injury to the personnel.

As a consequence, the pile positions have to be adjusted correspondingly to the changed and perhaps more unfavourable soil conditions so that the defined positions could have to be turned down, which could cause a project delay and considerable extra expenses.

Process step j):
Storage in the offshore port and the onshore assembly there

The provision of material and components for an onshore assembly in the offshore port involves a high potential risk; i.e. delivery of components is delayed.

The provision of material and components for an onshore assembly in the offshore port involves a high potential risk; i.e. the quality supplied by the suppliers is not reliable (not in compliance with product specifications, not on schedule).

The provision of material and components for an onshore assembly in the offshore port involves a high potential risk; i.e.unsuitable components and materials are installed, which - provided that this is revealed early - have to be dismounted and replaced.

Provision of personnel involves a high potential risk; i.e. the personnel recruited for onshore assembly in the offshore port is insufficiently trained and not skilled.

Process step k):
Offshore transports

The offshore transport "on own hull" involves a high potential risk regarding the buoyancy of the topside of the offshore transformer station in the wind farm. The topside can capsize and/or sink. This can cause damage to the topside and the equipment installed or even the total loss of the topside followed by delays throughout the entire project and damage to fixed and other floating objects and the environment.

Floating into position of the topside (separate and combined unit) involve another high potential risk; i.e. monitoring of the sea state and weather conditions shows a sudden change in the weather. This can entail too heavy wind and gusts, too rough sea(s), and too strong currents in the different depths of water.

This adversely affects installation of the anchor grid and connecting the mooring ropes to the anchor grid because this is impossible then. Moreover, it is possible that floating into position becomes impossible. This can cause a delay in positioning and installation.

Process step l):
Offshore erection

The jack-down procedure of the movable legs and alignment of the topside involve a high potential risk if this procedure is required. Here, the jack-up system can fail so that

- no jacking is possible at all,
- jack-up and installation become delayed.

Table 3: Distribution of the potential risks of the operations required to build the offshore wind turbines examined in the OCoP (WITHOUT and IN consideration of protection measures)

Potential risks	Potential risks of the examined operations w/o consideration of protection measures		Potential risks of the examined operations in consideration of protection measures	
	[number]	[percent]	[number]	[percent]
low risk	15	5	126	43
medium risk	117	40	156	53
high risk	142	48	13	4
very high risk	21	7	0	0

The jack-up procedure (in up direction) involves a high potential risk if this procedure is required. Here, the jack-up system can fail so that

- no jacking is possible at all,
- damage to the topside and/or the legs occurs if the topside has not been jacked up out of the tidal limit or wave peak (this is called slamming);
- jack-up and installation become delayed.

The jack-up procedure involves a high potential risk if this procedure is required. The hazard occurs during monitoring of the sea state and weather conditions when a sudden change in weather becomes obvious. This can entail too heavy wind and gusts, too rough sea(s), and too strong currents in the different depths of water. This adversely affects the jack-up procedure; i.e. this becomes impossible and damage to the topside by slamming can occur. This can cause a delay in jack-up and installation.

Lifting (lifting and depositing) of the topside involves a high potential risk if the transformer platform is deposited directly onto the foundation. This is the case if it is composed of small, separate units and work is effected with crane vessels and/or jack-up barges/vessels. Here, the topside can swing, twist, and touch down as a result of an uneven distribution of loads (either the centre of gravity is far beyond the vertical axis of the topside or by touching down onto the base frame / pile or any other structure). This can cause:

- falling of the spreader from the hooks,
- damage to the topside, the footing structure (base structure), the crane vessel, the barge, and/or other structures due to collision with the topside,
- a delay in lifting and installing.

Process step n):
Commissioning and test run until getting the PAC.

Commissioning of the medium-voltage switchgear involves a high potential risk if a fire cause damage to the medium-voltage switchgears, the transformers, or the connected electrical components. Synchronising faults are possible, too.

Electrical connection to the offshore transformer station of the transmission grid operator involves a high potential risk. There is the risk that fires and damage to the low-voltage, medium-voltage, and high-voltage switchgears, the transformers, and connected electrical components occur.

5.3 Offshore wind turbine

5.3.1 List of process steps under review

The building of the offshore wind turbine considered in the OCoP is composed of the process steps below:

a) execution planning of the soil investigation for locations of offshore wind turbines;

a) soil investigation for locations of offshore wind turbines;

c) execution planning of the inland transport (overland and rivers) from the factory to the offshore port;

d) execution planning of the storage in the offshore port and the onshore assembly there;

e) execution planning of offshore transports;

f) execution planning of offshore erection;

f) execution planning of residual assembly work offshore;

h) execution planning of the commissioning and the test run until getting the PAC;

i) inland transport (overland and rivers) from the factory to the offshore port;

j) storage in the offshore port and the onshore assembly there;

k) offshore transports;

l) offshore erection;

m) residual assembly work offshore;

n) commissioning and test run until getting the PAC.

5.3.2 Representation of significant risks when building offshore wind turbines

There have been 295 risks identified and assessed throughout the installation process of the offshore wind turbines in the wind farm. Most of them (about 55 %) are of high up to very high potential risk without consideration of protection measures, which, however, can reduce or prevent the risks.

The implementation of several protection measures mitigates the hazards of high to very high potential risk by about 51 %. Table 3 overviews the distribution of the potential risk in and without consideration of the protection measures.

The hazards showing a high to very high potential risk despite any protection measures are described below in detail with regard to the process steps. These are process step b), process step c), process step i), process step j), process step l), and process step n) because the other process steps have not shown any significant risks during erection of the offshore transformer station in the wind farm.

Process step b):
Soil investigation for locations of offshore wind turbines

A high potential risk occurs in case the actual soil conditions significantly deviate from the geological, geophysical, and geotechnical investigation results. The consequences are as follows:

- the ground does not prove the characteristics required for the planned foundation method (e.g. due to soft sediment lenses);
- feasibility of driving and footing (piling) due to the conditions of the sea ground is not ensured;
- insufficient levelling due to variations in the thickness of bearing beds (ruggedness);
- search for ammunition (not considered separately in the OCoP);
- objects and/or obstacles at the pile positions (e.g. wrecks, undersea cables, etc.).

These potential hazards can cause different adverse effects on the erection of the offshore wind turbines; e.g.

- an installation of the footing structure at the planned position is impossible so that the position has to be turned down;
- the ram piles cannot be rammed down to the planned depth;
- the ram piles can be subject to deformation;
- the ramming equipment can be damaged;
- the ram piles are unsuitable for the soil;
- the ram piles become stuck in the sea ground during ramming because they are blocked by objects;
- the OCoP has not considered the search for ammunition;
- risks for stability and usability can occur if the soil investigation has been insufficient.

Therefore, e.g. the positions of piles, their design, or procedures have to be adapted to the most unfavourable soil conditions as the case may be. This can entail project delays and considerable increases in costs.

Process step c):
Execution planning of the inland transport (overland and rivers) from the factory to the offshore port

Reservation of human resource and equipment capacity required for the inland transport of offshore wind turbine involves a high potential risk; i.e. any reserves for their/its availability have not been allowed for. Thus, personnel and equipment are available at stated times, only.

Reservation of human resource and equipment capacity involves a high potential risk; i.e. any reserves for the human resource and equipment capacity have not been allowed for. The number of personnel is sufficient; however, it has been calculated without any allowance for deviations. Mounting equipment and means are sufficient as to their output capacity; however, they are insufficient as to their output capacity if the load increases and cannot be used then.

Reservation of resource and equipment capacity involves a high potential risk; i.e. any redundancies for potential faults have not been allowed for.

Process step i):
Inland transport (overland and rivers) from the factory to the offshore port

The inland transport of tower segments involve a high potential risk; i.e. the tower could be subject to deformation due to an uneven load distribution.

Process step j):
Storage in the offshore port and the onshore assembly there

The check of the ram piles upon the inland transport as operation to prepare the offshore transport involves a high potential risk; i.e. the checks are not carried out in a workmanlike manner and, as a consequence, damage (e.g. due to improper transport, loading, and storage) is not detected.

The onshore assembly of the footing structure and the transition piece involves a high potential risk. If damage due to improper inland transport or improper loading is not detected, there is a high risk that the onshore assembly of the footing structure and the transition piece becomes impossible.

The onshore assembly of the three rotor blades and the rotor hub to the rotor star involves a high potential risk. Improper lifting, loading, or improper inland transports could have caused damage.

Process step l):
Offshore erection

The jack-down procedure of the movable legs until getting stability carried out by the jack-up barge/vessel during installation of the base structure of offshore wind turbines involves a high potential risk; i.e.

- the jack-up system could fail,
- the movable legs could sink unevenly deep into the seabed,
- the soil is inhomogeneous or erratic blocks (monoliths) could be there,
- jack-up procedures have been carried out there already (old foot print).

These hazards can adversely affect the offshore erection of offshore wind turbines; i.e.

- jack-up becomes impossible,
- the movable legs and the jack-up mechanisms could be damaged.

This can cause delays during jack-up and/or installation and entail additional costs.

The jack-up procedure of the jack-up barge/vessel during installation of the tower and the turbine of the offshore wind turbines involves another high potential risk; i.e. under load the movable legs sink unevenly deep into the seabed.

Process step n):
Commissioning and test run until getting the PAC.

The installation work, tests, checks, etc. carried out during commissioning involve a high potential risk. During installation etc., heat intensive tasks (welding, abrasive cutting, etc.) or e.g. the test run of electric devices in connection with fire load can cause fire and explosions. Increased fire loads, such as stored fuel quantities to run emergency generators, cannot be excluded and present an increased danger compared to standard operation.

There is a high potential risk if the external power connection is not available for installation work, tests, inspections, etc.

6 Conclusion and prospects

Starting from the objective of the present guideline as set out in detail in the preface we can conclude as follows from the risk analysis effected.

On the basis of the lists of risks drawn up we could gain an impression of the process steps and operations during erection and the risks coming along with them. The descriptions of significant risks are to be considered exemplary and not to be equated with the project specific requirements of the user. The user's attention is drawn to certain risks; however, s/he shall be able to transfer the significant risks with regard to the actual requirements upon a specific consideration of the project.

Taking protection measures can considerably reduce the risks during erection of an offshore wind farm. This accentuates the need for a preventive implementation of the risk management procedure.

There are mostly significant risks for individual operations during erection. The relevant protection measures to reduce or prevent the risks mostly refer to activities of execution planning and preparation. Thus, planning and preparation is essential for erection of offshore wind farms, for the execution of operations finally shows how good planning and preparation had been. Please note here that the hazards and risks of a single process step should perhaps be taken into account already when drawing up the first concept provided that they can be changed, e.g. by selection of a different design option.

In the trades offshore transformer station in wind farms and offshore wind turbines recurring risks occur in the process steps "soil investigations", "offshore erection", and "commissioning and test run until getting the PAC".

The meeting of more than 90 representatives of the offshore and the insurance business started within the scope of the OCoP initiative a dialogue regarding the erection of offshore wind farms with its main focus on the exchange of information on risks and possible protection measures. Here, particularly those coming from the industry learned about the necessity that the risk analysis should be even more detailed. For the lists of risks presented in the OCoP already give a first impression of the processes run, potential risks, and protection measures.

To minimise the scope of interpretation of a risk analysis or even prevent any interpretation at all, deepest information on hazards, risks, and protection measures are supportive. Such supplementary information could possibly be gained and provide for a uniform view of things with a procedure which is quite usual in the industrial sector. A possible procedure is e.g. the failure mode and effect analysis (FMEA), which again can be supplemented with the failure mode, effects and criticality analysis (FMECA).

The FMEA is a procedure to determine the kind of a failure, malfunction, damage, or potential fault. An FMEA or FMECA, respectively, proves advantageous because e.g.

- this is preventive quality assurance with its focus on the prevention of failures instead of their removal;
- this is a continuous cyclical improvement process;
- this can be applied to any stage in the lifecycle of a system, product, process, etc.;
- this is a systematised method, the results of which are documented in an easily readable manner;
- the systematised method results in a high level of detail to investigate on the one hand into the potential failures, the failure causes, and consequences / effects of failures. On the other hand, these are analysed regarding the relevance of the sequence of failures / effect, the probability of existence of the failure cause, and the probability of discovery of the failure;
- this provides for detection of significant and/or critical failures in e.g. a process and for establishment of measures to reduce and prevent such;[12]
- the (AdÜ: groß?) mentioned process steps of high risk require thorough planning of execution with adequate appreciation of the risks and development of the protection measures to be taken, which are perfectly adjusted to the offshore wind farm project.

12 Risk management -- Risk assessment techniques (IEC/ISO 31010:2009); German version EN 31010:2010, Page 45 et seq.; Methoden der Risikoanalyse in der Technik [Methods of risk analysis in technology]; Systematische Analyse komplexer Systeme [Systematic analysis of complex systems], Page 30 et seq.; Gefährdungsanalyse mit FMEA [Risk analysis with FMEA]; DIN EN 60812:2006-11

Furthermore, it would be reasonable to create a uniform understanding of how to apply risk assessment techniques in practice. For erection and other processes throughout the lifecycle of an offshore wind farm are very complex and extensive processes involving different actors or companies, respectively. The present OCoP shall provide for a common understanding of the importance of cross-trade and cross-company risk transparency and places a guide for practical use at your disposal. The FMEA is one possibility to put the findings obtained in the OCoP into action.

7 Literature / references

7.1 Suppliers

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VDE-Verlag GmbH
Bismarckstraße 33, D-10625 Berlin
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[3] Publications of GDV
[German Insurance Association]
Gesamtverband der Deutschen Versicherungswirtschaft e. V. (GDV)
Wilhelmstraße 43/43 G, D-10117 Berlin
www.gdv.de

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8 Annex

8.1 Glossary

Erection: The erection is one stage of the life cycle of products and/or offshore wind farms ranging from product development to recycling. The life cycle is subdivided into planning, external design, engineering and design, manufacture, erection, operation, repowering if required, dismantling, and recycling.

The erection in the OCoP chronologically refers to the inland transport (overland and rivers), the onshore assembly, the offshore transport, the offshore erection, the residual assembly work offshore, the commissioning, and the test run. As it is really important, the soil investigation within the installation process is listed as an excursus ahead of the inland transport.

Hazard: A hazard is an event, condition, or property presenting a potential source of damage and upon occurrence being of adverse effect on persons, material assets (buildings, operating

equipment, stocks, and plants), the environment - including costs and deadlines.[13]

Cabling in wind farms: Cabling in wind farms means laying the cables between the individual offshore wind turbines including their junction and connexion to the offshore transformer station in the wind farm.[14]

Marine Warranty Surveyor: The MWS is an independent expert. His/her main job is to ensure that the safety guidelines and goals are observed as well as to verify compliance with all procedures.

Offshore wind farm: Based on the definition of the the Federal Maritime and Hydrographic Agency - the BSH - offshore wind farms are composed of the main crafts below:

- Offshore wind turbine
- Cabling in wind farms
- Platforms (sub-stations), such as the offshore transformer station in wind farms, the offshore transformer stations (DC transformer station) normally operated by the grid operator, the living and working station, and other stations in the farm (met mast etc.)
- Undersea cable [15]

The OCoP covers the trades: offshore wind turbine, cabling in wind farms, and offshore transformer station in wind farms.

Offshore wind turbine: The offshore wind turbine includes the turbine itself and the support structure. The turbine is composed of the rotor and the nacelle. The support structure is composed of the tower and the base structure. Normally, the base structure is composed of the transition piece and the foundation including local fastening into the seabed (footing structure or pile).[16]

Offshore transformer station in wind farms: There are several constructions of offshore transformer station in wind farm. However, this stations is generally composed of a topside and a base structure (or base frame). In addition, the platform houses electrical components (transformers, medium- and low-voltage switchgears, etc.) technical safety equipment, ancillary equipment (cranes, helicopter deck, etc.). Normally, the base structure is composed of the foundation and the footing structure.

The offshore transformer station in wind farms may be designed in two different ways. These are the separate and the combined design. In separate design, the base structure and the topside are separate, i.e. transport and assembly can be effected separately. In combined design, the base structure and the topside are connected already before starting the offshore transport.

Project delays: Project delays result from a delayed completion (of the entire project) that is due to a compensable property damage (loss resulting from a delayed start-up) of the offshore wind farm and the following delay in getting the PAC.

Provisional Acceptance Certificate: The PAC is a formal procedure, at the end of which a certificate is issued attesting delivery of the works from the contractor to the customer. Thereupon the test run of the offshore wind farm ends.

Risk: A risk is the combination of probability of occurrence of a hazard causing a damage and the extent of damage.[17]

Risk in general means:

Risk = probability of occurrence x extent of damage[18]

Risk analysis: The risk analysis includes at least the estimation of the extent of damage and the probability of occurrence of the hazards determined through the risk identification. As a rule, this takes the existence and effectiveness of already existing protection measures into account.[19]

Risk assessment: The risk assessment compares the results from the risk analysis to the set targets, criteria, etc., which have been defined in AdÜ? This helps to make decisions regarding

13 Methoden der Risikoanalyse in der Technik [Methods of risk analysis in technology]; Systematische Analyse komplexer Systeme [Systematic analysis of complex systems], Page 8

14 Standard - Design of Offshore Wind Turbines, Page 5

15 Standard - Design of Offshore Wind Turbines, Page 5

16 Standard - Design of Offshore Wind Turbines, Page 11

17 ISO/IEC Guide 73 - Risk Management

18 Methoden der Risikoanalyse in der Technik [Methods of risk analysis in technology]; Systematische Analyse komplexer Systeme [Systematic analysis of complex systems], Page 8 et seq.

19 Risk management -- Risk assessment techniques (IEC/ISO 31010:2009); German version EN 31010:2010, Page 11 et seq.

the necessity and implementation of protection measures to reduce and prevent the risk.[20]

Risk identification: The risk identification means searching for, detection, and recording of hazards with regard to their causes and effects.[21]

Risk management: Based on DIN EN 31010, risk management means rating and control of risks so as to be able to cope with the risks inherent to an organisation, a process, etc. The risk management is a systematic, cyclical, continuous improvement process. This should be repeated again and again until the potential risks will have reached acceptable levels on the one hand and to take into account any project changes resulting in the course of time on the other hand. Thus, this is repeated again and again until the potential risks will have reached acceptable levels on the one hand and to take into account any project changes resulting in the course of time.[22] (AdÜ: Überflüssig - siehe 1 Satz weiter oben?)

Property damage: Property damage results from the damage to or destruction of an object.

Protection measures: These are preventive measures taken to reduce or prevent a risk. This means, that the protection measures can both, reduce the probability of occurrence of a hazard and cut down the extent of damage.

8.2 List of abbreviations

BSH Bundesamt für Seeschifffahrt und Hydrographie [Federal Maritime and Hydrographic Agency]

DC direct current

EWTC European Wind Turbine Committee

FMEA Failure Mode and Effect Analysis

FMECA Failure Mode, Effects, and Criticality Analysis

GDV Gesamtverband der Deutschen Versicherungswirtschaft e. V. [German Insurance Association]

MWS Marine Warranty Surveyor

OCoP Offshore Code of Practice

PAC Provisional Acceptance Certificate

8.3 List of companies involved in the risk analysis

This is the opportunity to thank anyone involved in the development of the OCoP for his/her cooperation and commitment!

On Page 3 of the OCoP, you will find a list of the companies involved in the risk analysis

8.4 Explanatory notes on the lists of risks

The risk analysis made together with representatives of the offshore wind power industry is fundamental to the guideline. This is the definition and assessment of risks and relevant protection measures for any important operation. Documentation was effected into corresponding lists of risks revealing the significant risks.

The instructions on how to proceed (see Table 4) inform on how to analyse the risk and draw up a corresponding list. These were used among other things as a guide in the meetings of the work groups to perform the analysis and note down the results.

20 Risk management -- Risk assessment techniques (IEC/ISO 31010:2009); German version EN 31010:2010, Page 14

21 Risk management -- Risk assessment techniques (IEC/ISO 31010:2009); German version EN 31010:2010, Page 10

22 Risk management -- Risk assessment techniques (IEC/ISO 31010:2009); German version EN 31010:2010, Page 5 et seq.

Table 4: Instructions on how to proceed in the risk analysis and drawing up the lists of risks.

Column header	Explanatory notes on how to fill the cells of the list of risk
Id (manual entry)	A common identification code is assigned to the process steps and, thus, to the corresponding operations so that later selection of an entire process step will be possible. The identification code of the process step is composed of letters. This has been defined for each process step and cannot be changed by the user.
Name of the process step (manual entry)	This is a catchy header describing the process step. The process steps have been selected so that they can be differentiated from each other. Those corresponds to the differentiations of work groups 1 through 3 so as to allow corresponding allocation of the packages. The descriptions of the different process steps have been defined for each trade and cannot be changed by the user. *Example: Execution planning of offshore transports*
Short description of operations (manual entry)	Each process step can be followed by any number of operations and their descriptions. Each operation gets an own line. *Example: Planning of necessary barges / tugboats; planning of necessary sea-fastening; manpower planning MWS; etc.*
Description of hazards (manual entry)	Detailed description of any important hazard, which could occur during the corresponding operation. Several hazards per operation are possible. Each hazard described gets an own line. *Example: Barge unsuitable for mass of footing structure; loss of footing structure due to unfavourable wind conditions / sea state; loss of footing structure due to poor sea-fastening; etc.*
Assessment: risk (manual entry)	Assessment of the risk without consideration of the protection measures listed below. The assessment classifies into 4 categories: ■ low risk ■ medium risk ■ high risk ■ very high risk The assessment is made in view of the extent of property damage and loss due to delay as well as of the probability of occurrence based on the experiences the participants of the work group have gained. As to the property damage and losses due to delay, the potential financial loss has been estimated.
Description of protection measures (manual entry)	For each listed hazard, possible protection measures are named, which can reduce the probability of occurrence and/or cut down the extent of damage. It is possible that a sufficient protective effect can be reached only with a combination of several protection measures. Point to this in the field for comments. Each protection measure described gets an own line. Even if in practice further protection measures are possible, the number of protection measures for the risk analysis ought to be limited to 5. *Examples: Defining max. wind speeds and/or wave heights for transport of the footing structure; approval of sea-fastening by MWS; defining the minimum weather slot when transport and depositing in the target area shall be complete; etc.*

Column header	Explanatory notes on how to fill the cells of the list of risk
Assessment of protection measure (manual entry)	How effective is the protection measure and can it reduce the risk? The assessment classifies into 3 categories: ■ very good ■ adequate ■ poor The effect of a protection measure is very good if taking the measure almost excludes the risk resulting from a hazard (damage to property / loss due to delay) as far as our experience goes; i.e. if the risk can be controlled. The effect of a protection measure is adequate if taking the measure noticeably reduces the risk resulting from a hazard (damage to property / loss due to delay) as far as our experience goes. The protection measures noticeably cut down the risk. The effect of a protection measure is poor if taking the measure hardly reduces the risk resulting from a hazard (damage to property / loss due to delay) or does not reduce it at all as far as our experience goes, i.e. the risk will persist although the protection measure is taken. The assessment of the effectiveness of protection measures is also based on the experiences the participants of the work group have gained.
Relevance (automatic entry - calculation field)	The risk relevance is automatically calculated from the risk assessment and the assessment of the effectiveness of a protection measure and classified into 12 grades. The higher the relevance, the larger the damage to be expected or the delay when the risk come true.
Risk status (automatic entry - calculation field)	The risk status informs about the potential risk in consideration of the aforementioned protection measures. The assessment automatically classifies into 4 categories: ■ low risk ■ medium risk ■ high risk ■ very high risk. The automatic calculation of the risk status uses the relevance grade. If the desired protection objective can be reached only by taking several protection measures to compensate for a risk, any of the protection measures involved are to be classified "low risk". However, in such a case a comment on the common establishment of the protection measures has to be given in all comment fields.
Comments (manual entry)	Supplementary description of the risk or the protection measures so that any third person not being involved (fundamentals in the field assumed) is able to understand the statements. Upon completion and evaluation of the risk analysis, these comments shall be of assistance when writing out the OCoP in full.

9 Lists of risks

9.1 Offshore transformer stations in wind farms

9.1	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	c)	Planning of transport	No planning of individual transport stages	high
	c)	Notification of insurer Designation of warranty surveyor	Notification of insurers / warranty surveyors too late Present risk analysis only applies to first transport stage (e.g. until unloading in seaport) Required transport eyes or necessary protection against environmental impact offshore missing Once the cargo is ready, the expenditure for an optimum adjustment to the necessary changes is often inacceptable - from the economic point of view Thus, acceptance of compromises resulting in cutbacks of safety standards Unplanned delays result Already rented transport means and hoists could be lacking then	medium
	c)	Determination of final transport route	Impracticability and/or considerable delays due to missing or poor planning of the entire transport route	high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.1
Draw up a transport manual for all stages, start with the manufacturer and end up with the final destination Risk analysis with protection measures per stage Emergency planning / emergency locations per stage	very good	3	low risk	Avoid organisation blindness by old hands	
As soon as the insurer has received a request for coverage: ▪ Entrust inspector with preliminary examination of the transport concept ▪ Require method statements just being developed for the different handling and lifting procedures ▪ Request submission of rough calculations of the fastening points for lifting and securing of cargo ▪ Request submission of the specific criteria for transport of the cargo	very good	3	low risk	Very often the insured hires several sub-contractors with even more sub-contractors It takes a lot of time until the chain of suppliers and their responsibilities will be clear and the surveyor will have the necessary documents on hand Beyond doubt, each sub-contractor / forwarding agent is an expert in its field But this does not inevitably mean that the particularity of the following stage is recognised Therefore, an inspection company shall examine the issues of the entire transport chain	
On the basis of the scheduled transport date: Entire transport route / transport chain shall be on hand The inspector examines any method statement for any single route and any single lifting procedure The inspector verifies the risk analysis and the protection measures for any single stage including the planned emergency locations and emergency measures Verification of the calculations of the fastening points for lifting and securing of cargo and examination of the sling gear to lift and of the securing of cargo The inspector checks for potential compliance with the specific criteria of the cargo for transport under the planned conditions	very good	3	low risk		

9.1	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	c)	Pre-check of trans-port route	Unpracticability of transport due to hindrances on the transport route	high
	c)	Selection of transport means per stage	Insufficient stability of the transport means with cargo Unsuitable for selected transport route	high
	c)	Preparations for transport of the cargo	Insufficient protection by packaging Changing environmental impact on different stages and transport means (road, inland waterways, open sea) not taken into account when preparing for the transport The shipping inserts, the external packaging of cargo, and the securing of cargo on the corresponding transport means and per stage not always proper	high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.1
Proof for checks of route sections (maximum allowed load on roads, bridges, etc. as well as turning radii of bends) Locations where temporary dismounting of obstacles is required and corresponding permits on hand? Appropriate companies hired for such dismounting? List of measures to be taken in case of too high or too low water levels Corresponding weather forecast on hand? Sufficient crane capacities at the planned transhipment points, passageways under bridges, etc. provided for?	very good	3	low risk		
Calculation of stability of the transport means with cargo Check whether the transport means with cargo is able to move on the transport route proving the actual stability	very good	3	low risk		
Check whether packaging suits the transport Check whether weather conditions and mechanical load could affect transport and the properties of the cargo Packaging shall be adequate to the required protection grades of the cargo and meet the highest requirements of weather impact and mechanical load during the entire transport from the manufacturer to the final destination The inspector shall check the corresponding stage and the critical influences of other stages on this If for reasons of logistics and/or practicability, the packaging as well as the shipping inserts and/or the external securing of cargo is made per stage, only, corresponding logistic, technical, and organisational measures shall be taken between the stages I.e.: ▪ Storage sites of sufficient ground load-carrying capacity ▪ Crane capacities and the required lashings and packaging material shall be available	very good	3	low risk	Existing standards to be checked for their applicability to the respective cargo Packaging shall suit sea transport to prevent repackaging prior to this As a rule, the sea transport is the decisive element for preparation of the cargo for transport	

9.1	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	c)	Check of weather criteria and other restrictions for any stage	Missing description of the external influencing factors on the cargo to be avoided	high
	c)	Definition of inter-faces regarding the transfer of risk	Responsibilities of the actors (companies, persons on site) insufficient-ly depicted	high
	i)	Cargo subject to handling several times during the transport (e.g. from road to train, to river boat, to road, and so on)	Different risk potentials depending on the transport means and route not taken into account for preparations	high
	i)	Cargo subject to handling several times during the transport (e.g. from road to train, to river boat, to road, and so on)	Mounting and dismounting the securing of cargo several times may weaken the securing arrangements	high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.1
The manufacturer shall state definite maximum and minimum values for: temperature, air humidity, purity of ambient air, susceptibility to shock, angle of inclination, acceleration, sensitivity in contact with other substances Which goods of which hazard classes shall not be stored in the same room or near the cargo? Where are emergency and alternative locations to provide for sufficient protection when the weather gets worse?	very good	3	low risk	Information by manufacturers are taken as a basis to draw up a transport manual Information by manufacturers widely influence the planning of transport Consequently, the transport route better should be roughly defined in the design stage already This includes definition of the optimum season for transport Reliability of weather forecasts etc. depends on the season, too	
Clear definition of the transfer of risk and, consequently, clear definition of the responsibilities by naming the responsible companies and persons Check of standard handling procedures, e.g. from the workshop to first transport means with object-related adjustment	very good	3	low risk	For such transports, the manufacturers should be involved as they know the characteristics of the cargo very well In particular if the manufacturer modified the cargo compared to the previous one An inspector should accept the transport concept and securing in advance and on site	
Compulsory elaboration of an independent procedure incl. risk analysis in accordance with the standards for transport on roads and inland waterways for each transport means and each handling of cargo An inspector should verify the procedures very early If required, the inspector should accompany on the spot the execution of transport and handling	very good	3	low risk	Any handling of cargo involves a risk as the cargo is handled and/or moved against its purpose	
Check of condition of the materials used prior to any use and check of the guaranteed lifetime of materials As an alternative, use of a new one-way material	very good	3	low risk	Already when designing the cargo, the possible fastening points for securing attachments shall be calculated and designed For an optimum design of the fastening points, also the material for securing of cargo should already be defined	

9.1	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	i)	Loading of cargo	Improper sling gear and lifting equipment	high
	i)	Execution of trans-port	Unforeseeable changes during transport	high
	i)	Execution of trans-port	Interruption of transport due to malfunctions of the transport means and/or road damage or accidents of other vehicles	high
	i)	Execution of inland and river transport	Inappropriate use of transport means, e.g. for salvage of third parties	medium

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.1
TÜV and/or the class have provided standards for calculation of the required sling gear and lifting equipment Inspection of the lifting equipment and sling gears by an inspector as required in the applicable standards by DIN and VDI The inspector verifies whether all criteria with influence on the dimensions of a sling gear have been taken into account when calculating such dimensions Visual inspection of sling gears and lifting equipment on site	very good	3	low risk	The documents are of limited validity The equipment and sling gears shall be subject to regular inspections by the TÜV / class The inspector should carry out a visual inspection immediately before any use	
The inspector is immediately notified of any deviation from the planned route and/or procedure according to the transport manual If required, the inspector shall immediately travel to the site to inspect the required deviations	very good	3	low risk	Impossible to allow in a concept for any incalculability In exceptional cases, the customer often decides on the costs only and not on the aspect to meet the insurers' requirements	
Immediate notification of the inspector who looks in the transport manual for an emergency plan provided for the very situation The inspector shall be consulted about the conditions for continuing transportation If the stacking area / the emergency site has not been inspected so far, this shall be done immediately (protection against damage, ground load, crane capacities, protection against environmental effects, etc.) Perhaps allow for alternative transport means	very good	3	low risk	If the following transport means is not available for a short period, intermediate storage shall take place If a mobile crane has been planned for cargo handling, this crane shall also be available later	
The transport means cannot be used for rescue operations when being loaded Should there be threat to life, think over an alternative first Implement a corresponding provision in the transport agreement	very good	2	low risk	It is quite usual that river boats help each other without posing questions Sometimes this is done to get free way on the river	

9.1	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	i)	Loading of inland ship	Insufficient stability of the transport means with cargo	small
	i)	Loading of inland ship	Dangerous goods transport on the river boat in the same cargo compartment Based on certain classes of hazard this increases the danger for the entire transport means including the cargo	high
	i)	Execution of trans-port	Interruption of transport due to malfunctions of the transport means and/or insufficient water depth	small
	c)	Preparations for loading	Particular transport means and loading itself depends on the weather In case of unfavourable weather conditions (storm, ice, flood or low water), transport cannot be realised as planned Pursuant to the agreement the required lifting equipment is available for a certain time only	small

Protection measures	Assessment of protection measures	Relevance	Status	Comments
Determine the centres of gravity and the lever arms affecting stability Check and prove loaded condition of the ship Deliver evidence for sufficient water depth along the entire waterway	very good	1	low risk	The calculation of stability is not as detailed as for sea vessels For loading of river boats, only the Plimsoll mark is decisive However, if the centre of gravity of the cargo is too high, a larger inclination of the river boat can cause a list with hazardous water inrush into the cargo compartment This problem is not well known in the inland water transport industry Only since containers have been transported on river boats and two large accidents on the Rhine were due to instability, this issue has received attention
Prior definition, which dangerous goods are allowed by their class of hazard to be transported together with the transformer	very good	3	low risk	Rather hypothetic risk
Calling at stacking area / emergency sites as defined in the transport manual If impossible to call at the planned emergency areas / sites, an alternative shall be found in cooperation with the inspector	very good	1	low risk	Rather low risk Problematic in case of collisions However, a reasonable emergency concept for such a case cannot be established But there are enough boats and emergency sites on the river to start rescue measures immediately
This problem is part of the transport manual, the risk analysis, and the protection measure Inform the inspector who shall see to a realisation in accordance with the transport manual	very good	1	low risk	The transport manual also covers provision of time-critical lifting equipement depending on the season The corresponding protection measure of the transport manual should provide for a variant, for the realisation of which the required lifting equipment will be available at once There are reliable weather statistics that are adequate for overland transport

9.1

Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
j)	Planned storage	The storage site does not correspond to the required protection measures	small
j)	Execution of assem-bly	Fault of equipment and devices required for assembly	very high
j)	Provision of material and components	No specialists	very high
j)	Provision of material	Failure of basic supply for operation (e.g. power supply, working media)	very high
j)	Execution of assem-bly	Fire	very high
j)	Execution of assem-bly	Natural hazards (lightning, storm, heavy rain, ...)	very high
j)	Execution of assem-bly	Lightning	very high
j)	Execution of assem-bly	Storm	very high
j)	Execution of assem-bly	Sabotage	very high
j)	Provision of material and components	Delivery of components delayed	very high
d)	Selection of assem-bling site, equip-ment, and devices	Planning basis not subject to standards	high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.1
The transport manual specifies appropriate locations / sites for planned intermediate stops that have been verified in advance This shall also apply to unplanned stops corresponding to the protection measures defined in the transport manual If other sites have to be used nevertheless, the inspector shall be informed immediately Then, corresponding measures will be taken on site	very good	1	low risk		
Provision of redundant equipment and devices, regular maintenance	very good	4	medium risk		
Contingency personnel planning	very good	4	medium risk		
Provision of emergency supply according to the emergency plan	very good	4	medium risk		
Fire protection concept and measures for the assembling workshop and assembling site including the partially assembled platform	very good	4	medium risk	Generally required and of higher level	
Protection measures for work involving fire risk (fire permit procedure / process manual)				Only regarding the prevention of an outbreak of fire during welding	
Fire protection during building - depending on design and project				In the construction stage, only	
Protection measures against events to be expected, incl. drawing up an emergency plan and keeping this up-to-date	very good	4	medium risk		
Lightning protection for assembling workshop and outdoor assembling site with any partially assembled platforms	very good	4	medium risk		
Additional protection measures when a storm approaches, e.g. protection of scaffolds and cranes	very good	4	medium risk		
Intrusion protection (fences, illumination, monitoring with cameras, safety service and security personnel, etc.)	very good	4	medium risk		
Find possible alternative suppliers during planning already Include necessary time allowance in scheduling	adequate	8	high risk		
Standardise planning basis	very good	3	low risk		

9.1

Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
d)	Construction engineering (method statements, material, personnel, components, lcoation)	Poor construction engineering	very high
j)	Execution of assembly	Poor compliance with set dates	very high
j)	Execution of assembly	Quality problems entailing time-consuming reworking	very high
d)	Draw up emergency plans	Preparations for emergencies missing although such emergency entails considerable delays (e.g. because of instructions by authorities)	high
j)	Execution of assembly	Insufficient co-ordination leading to mutual impediment of the different trades and, consequently, to delays and quality problems	very high
j)	Execution of assembly	Delay due to open interfaces between the involved parties	very high
j)	Provision of material and components	Installation of unsuitable components and materials that could have to be dismounted and replaced	very high
j)	Provision of material and components	Suppliers are not reliable	very high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.1
Possibility of preassembling depending on the shipyard capacities and the transport option (onshore if possible, offshore in exceptional cases, only) Make sections / modules depending on the transport/lifting options Allow for and co-ordinate all required operations and stages and processes Allow for the working spaces required as a function of the assembling progress	very good	4	medium risk		
Careful and prudent scheduling in consideration of the typical assembling conditions (e.g. weather conditions for work, e.g. coating not outdoor, potential fluctuation of capacities by other companies) Schedule supervision	very good	4	medium risk	Prerequisite for schedule supervision	
Quality control along with assembling (e.g. weld seams, steel sections, etc.) Partial acceptances acc. to ITP (installation and test plan, already drawn up in the design stage)	very good	4	medium risk	Self-checks and partial acceptance to be co-ordinated and complementary	
Emergency plan (shipyard and companies involved, logging of present persons for safe evacuation)	very good	3	low risk		
Designation of a competent chief of assembling to co-ordinate assembling with construction managers, suppliers, and customers and checks going along with assembling (QA, QC, teamwork of the involved trades and companies, deadline, quality, and documentation) Clearly stipulate by contract the responsibilities Clearly stipulate by contract the transfer of risk	very good	4	medium risk		
Designate a competent project controller Where possible, design, manufacture, transport, and assembling, as well as installation from one single source Place order for main components promptly so that early co-ordination is ensured	very good	4	medium risk		
Receipt control of materials and components regarding their fitness for the particular purpose "offshore" (manufacturer's declaration)	very good	4	medium risk		
Traceability of material and components (e.g. steel)	adequate	8	high risk	Does not take effect immediately, but educational effect	
Select appropriate suppliers (QA, QC, deadlines, references, assessment reg. solvency, too)	adequate	8	high risk		

9.1

Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
j)	Provision of perso-nnel	Work done by unsuitable personnel	very high
g)	Scheduling as well as provision of plan "B" with changed time schedule for the residual assem-bly work offshore	Corresponding scheduling of the assembly work onshore in compli-ance with the corresponding time slot Depending on time slot, season, weather forecast the transformer platform is transported earlier into the wind field and, therefore, the residual assembly work is more extensive than scheduled or deviates from the time schedule	high
g)	Scheduling of residual assembly work after erection in wind farm (following arresting and grouting of the platform)	Poor planning of residual assembly work with possible damage to the transformer platform	high
m)	Hand-over (removal of equip-ment and new set-up) of transport / installation to following trades / companies	Non-compliance involves the risk that necessary equipment, such as temporary fire protection, or other necessary equipment or protec-tions are not available	high
m)	Residual assembling of the platform in the wind farm	Upon transport / installation and prior to starting the residual work it is not clarified whether rooms have been sealed hermetically Rooms not sealed hermetically	medium
m)	Cable connection Connection to corre-sponding component (socket)	Dirty and humid connections / plug-type connections	medium
n)	Cold commissio-ning of transformer platform in the shipyard (onshore) What to be done offshore?	Damage to transformer platform	medium

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.1
Select appropriate assembling personnel (e.g. personnel by the manufacturer, potential criterions: professional training, experience, instruction / briefing)	adequate	8	high risk		
Early draw up plan "B" in advance (when foreseeable that the planned deadline will not be observed - approx. 6 months before scheduled time of shipping) incl. a risk analysis (e.g. deviating fire protection, logistics, materials, storage, etc.) Identify any work that can only be done onshore so as to effect them onshore	adequate	6	medium risk		
Draw up process flow scheme with any work to be done (incl. responsibilities, required personnel and material, safety regulations) as well as its effect on other trades	adequate	6	medium risk		
Comply with HSE rules and regulations (customer, authorities, etc.), e.g. welding only after compliance with all rules and regulations	very good	3	low risk		
Temporary measures correspond to the manufacturer's requirements; they shall be taken to ensure the required protection at any time	very good	2	low risk		
Compliance with instructions for erection	very good	2	low risk		
HAC (Harbour Acceptance Test, with MWS) onshore and prerequisite for transport; SAC (Sea Acceptance Certificate) offshore and prerequisite for commissioning of transformer platform	very good	2	low risk		

9.1

Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
m)	Pumping over of transformer oil from the drums for transport into the transformer in the wind farm and other filling of systems (e.g. fuel)	Escaping oil: ▪ Hazard class ▪ Ecological hazard ▪ Spillage of or damage to other components ▪ Cleaning expenditure on transformer platform	high
m)	Removing all devices securing the equipment on the platform	Damage to single components during the test run	high
m)	Offshore welding on platform	Fire hazard and damage	high
m)	Coating Corrosion protection	Fire hazard and environmental damage	medium
m)	Installation of equipment, such as pumps, ladders, etc. without welding	Damage to transformer platform	small
n)	Activation of fire detection / fire alarm and extinguishing equipment	Release of extinguishing equipment	small
n)	Installation and check of earthing system	Damage to all electrotechnical components and life safety at risk	high
n)	Activation of power supply systems	Fire hazard and damage to cabling and power supply units	high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.1
Comply with requested procedures and check the corresponding work equipment for any damage Make available and install any precaution for handling of oil (e.g. oil binder, collection tray, etc.) before starting it Observe the requirements and standards issued by the erecting party Measures requested in national and international rules and regulations regarding pollution with oil shall be taken	adequate	6	medium risk		
Execute item per item on the check list to remove the securing devices (as required by manufacturer where specified)	very good	3	low risk		
Comply with process flow scheme for welding and defined regulations (fire protection etc.)	adequate	6	medium risk		
Comply with process flow scheme for coating and defined regulations as amended (fire protection etc.)	very good	2	low risk	Active cathode protection Check connection with group 3 (activity to be done by group 3?)	
Comply with process flow scheme for installation and defined regulations	very good	1	low risk		
Lock the extinguishing medium prior to connection	very good	1	low risk		
Comply with process flow scheme for installation and defined regulations	very good	3	low risk		
Comply with process flow scheme for installation and defined regulations Specialists for power supply systems and medium-voltage switchgears with corresponding permission (adÜ) required Visual inspection and check of insulation of the units and cabling Check of the load switch in the outgoing panel to the medium-voltage switchgear (opened and filled with SF6) Connect power supply of single units at no load down to the outgoing panel to the bus bar	adequate	6	medium risk	Checking and ensuring functions (network stability, fire protection, safety cut-off)	

9.1	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	n)	Commissioning of medium-voltage switchgear	Fire, damage to medium-voltage switchgears, transformers, as well as electrical components connected Synchronising faults possible	very high
	n)	Commissioning of low-voltage switch-gear	Fire hazard and damage	medium
	n)	Commissioning of transformers	Fire hazard and damage	very high
	n)	Commissioning of high-voltage switch-gear	Fire hazard and damage	very high
	n)	Electrical connec-tion to the "North Sea outlet"	Fire, damage to low-, medium-, high-voltage switchgears, transfor-mers, as well as electrical components connected	very high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.1
Comply with process flow scheme for installation and defined regulations Specialists for power supply systems and medium-voltage switchgears with corresponding permission (adÜ) required Visual inspection and check of insulation of the medium-voltage switchgear and cabling All outgoing panels of medium-voltage switchgear in open condition and filled with SF6 Connect power supply of single units at no load to the bus bar Check monitoring of bus bar system protection Synchronise power supplies through medium-voltage bus bars	adequate	8	high risk		
Comply with process flow scheme for installation and defined regulations Visual inspection and check of insulation of the low-voltage switchgear and cabling All outgoing panels of low-voltage switchgear in open condition Successive connection of single loads with function test	adequate	4	medium risk		
Comply with process flow scheme for installation and defined regulations Analysis of the shock recorders Check of insulating oil (oil level, reading of breakdown voltage, reading of humidity content) Visual inspection and check of insulation of the transformer and cabling as well as check of corresponding protection of power system Check of the load switch in the outgoing panel to the high-voltage switchgear (opened and filled with SF6) If it is possible to connect through (no other consumer) to the transformer to be started up for the first time with the emergency generator, it is recommended to energise the emergency generator slowly until the transformer will have reached the nominal voltage	very good	4	medium risk		
	very good	4	medium risk		
	adequate	8	high risk		

9.1

Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
n)	Lacing (electrical connection of cables in the wind farm) and connection of first cluster	Fire hazard and damage	high
n)	Lacing (electrical connection of cables in the wind farm) and connection of following clusters	Fire hazard and damage	high
n)	Test run of single main components prior to overall test	Fire hazard and damage	high

Legend
a) Execution planning of the soil investigation for the site of the offshore transformer station in the wind farm
b) Soil investigation for the site of the offshore transformer station in the wind farm
c) Execution planning of the inland transport (overland and rivers) from the factory to the offshore port
d) Execution planning of the storage in the offshore port and the onshore assembly there
e) Execution planning of offshore transports
f) Execution planning of offshore erection
g) Execution planning of residual assembly work offshore
h) Execution planning of the commissioning and the test run until getting the PAC
i) Inland transport (overland and rivers) from the factory to the offshore port
j) Storage in the offshore port and the onshore assembly there
k) Offshore transports
l) Offshore erection
m) Residual assembly work offshore
n) Commissioning and test run until getting the PAC

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.1
	adequate	6	medium risk		
	adequate	6	medium risk		
	adequate	6	medium risk		

9.2 Cabling in wind farms

9.2	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	b)	Route survey	Crossings and adjacent media	very high
	b)	Route survey	Danger from soil and ground	high
	c)	Planning of resour-ces	Inappropriate resources Resources not available	very high
	c)	Planning of cable protection systems Scour protection	Damage to cable	high
	c)	Release of cable installation by the person in charge of project certification	Standstill No permit	medium

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.2
Identification of crossed media (cable, pipeline, ...) Complying with recommendations (e.g. ICPC) Determination of position of the crossing media (cable, pipeline, ...) Entering into crossing agreements Transfer into execution planning	very good	4	medium risk	Improper execution planning for cable crossings involves the risk of damage to the installed cable and/or to the medium to be crossed The mentioned protection measures prevent meeting with unknown media during execution, that an execution is not possible at all, or that a damage occurs The cable installer should be involved (AdÜ: DE unvollständig) when drawing up execution planning	
Select and execute of soil surveys and route survey in accordance with the BSH guideline "Ground Investigations for Offshore Wind Farms" latest edition (AdÜ: In DE gibt es eine Version von 2014, in EN nur von 2008?!) Analysis of the survey together with any information by third parties (e.g. areas with ammunition; description of nature protection, cable maps, wreck maps, archaeology) Analysis of the survey as to the suitable installation methods, installation equipment, and the appropriate installation depth (e.g. burial assessment, sediment shift)	very good	3	low risk	The BSH standard is under review at the moment to become more detailed; publishing date not yet known Selection of the installation equipment should be based on the results of the survey and not only depend on availability of the equipement.	
Enquire the installer about corresponding experiences Check the ship and the installation equipment for technical suitability for the tasks and the sea area (weather, soil) Experience of the personnel with the installation equipment Examine and assess complications of the past Check relevant certificates against the corresponding purpose of use / the corresponding area of use Provide for sea trials	adequate	8	high risk	Changes of equipment and personnel are rather normal, not an exception Duty to obtain consent from employer when equipment changes (equivalent) Ensuring protection measures even in the project execution stage	
Design and length of cable protection system in consideration of the calculation results of scour dimensioning	very good	3	low risk	Consider that enough free space for assembling of the cable protection system is available on the deck of the cable layer Reference to group 2: Erection of wind turbine / scour protection	
Always submit method statements / procedures early to the person in charge of project certification for verification and release	very good	2	low risk	Execution planning 3. release by BSH	

9.2

Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
f)	Option: onshore inspection (after transport to offshore port)	Damaged cable	small
f)	Storage of ready-made cable	Damaged cable	small
f)	Storage of ready-made cable	Fire	small
f)	Storage of ready-made cable	Theft Vandalism	medium
f)	Loading of cables	Damaged cable	medium
b)	Soil preparation (geotechnical investi-gation)	UXO (unexploded ordnance)	very high
b)	Soil preparation (geotechnical investi-gation)	Wreck Large obstacle	small

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.2
Inspect in accordance with concerted inspection schedule (e.g. high-voltage inspection, visual inspection) Quality check before and after each re-reeling after Factory Acceptance Test Observe how many times re-reeling may take place Turntables matched	very good	1	low risk		
Proper storage according to applicable Cable Handling Guidelines and any arrangements End-cap the cables Cover the stacks of cables	very good	1	low risk	Normally, sea cable provide an external layer made of PP yarn Long storage of this yarn can lead to aging and/or porosity due to direct sunlight (UV radiation) But this does not affect the integrity of the cable system	
No source of fire and fire load around the stored cable Complex separation	very good	1	low risk		
No storage in public areas Video surveillance, fencing, patrolling, and intruder alarm system for storage outside the plant site	very good	1	low risk		
Inspect in accordance with concerted inspection schedule (e.g. visual inspection, conduction test, OTDR reading) Quality check before and after each re-reeling after Factory Acceptance Test Observe how many times re-reeling may take place Match turntables, cable machines, and personnel	very good	2	low risk	Observe how many times re-reeling takes place	
Based on the pre-lay survey results and the requirements by authorities an UXO survey of the planned cable routes is required and where necessary explosive ordnance disposal (EOD) in a correspondingly wide corridor (determined by the installation equipment)	very good	4	medium risk		
Execute a PLGR while permanently monitoring the tractive forces, shortly before installation Reroute the cable where required	very good	1	low risk		

9.2

Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
c)	Selection of equip-ment for laying of cables	Unsuitable	very high
c)	Emergency planning for perhaps required interruption of laying Contingency planning	Effect by natural hazards	very high
c)	Emergency planning for perhaps required interruption of laying Contingency planning	Malfunction of equipment for laying of cables	medium
f)	Watertight end caps for laying the cable into the sea Wet storage	Permeability Water penetrates into the single wires of the sea cable	high
f)	Cable installation in the wind field	Standstill of laying spread (AdÜ? - marine spread: means the marine part of the Survey Equipment, with all appurtenances thereof, together with captain, full crew and technical team to be mobilised and used on site upon repair of the cable due to a damage	high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.2
Enquire the installer about corresponding experiences Check the ship for technical suitability for the tasks and the sea area (weather) Experience of the key personnel with the installation equipment Examine and assess complications of the past Check relevant certificates against the corresponding purpose of use / the corresponding area of use Provide for sea trials Check the cable installation method / cable laying equipment regarding the structure of the ground	adequate	8	high risk	For the time being not enough suitable cable layers available in the market Only the provision of references does not prove quality - this is insufficient and does not replace the protection measures The risk status only applies if all listed protection measures have been taken to 100 % Cable installation methods: ▪ Post lay burial ▪ Simultaneous lay and ▪ burial or pre-trenching	
Define and select stopping criteria and suitable weather slots for all stages of cable installation Select an appropriate port of refuge (e.g. little distance) Select and provide appropriate, local weather reports and forecast Procedure for laying the cable down onto the seabed Provide for end caps and fittings Safety measures for cable ends (e.g. buoys, guard vessel)	adequate	8	high risk	The restrictions due to weather must be so that securing of cargo and ship is possible But any delay due to bad weather often increases the overall project costs and, therefore, the risk remains a "medium risk"	
Design systems redundantly Procedure for laying the cable down onto the seabed Provide for end caps and fittings Safety measures for cable ends (e.g. buoys, guard vessel)	very good	2	low risk		
Development, design, and construction of a high-quality seal for the particular cable type (laydown head) according to the assembly instructions on hand by trained and skilled personnel	very good	3	low risk	Penetrating water causes damage or accelerates ageing of the cable insulation Later drying of an already installed and damp cable is impossible	
Analysis of known damage and early development and certification of appropriate procedures aiming at securing of the cable during any offshore repair work Provide for adequate resources	very good	3	low risk	The aim shall be quick and persistent repair of potential damage	

9.2	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	f)	Cable installation in the wind field	Loss of transmission possibilities due to a damaged cable and its repair	very high
	f)	Release of cable laying procedures by MWS	Standstill Damage Possible effects on the design of insurance coverage	high
	c)	Drawing up procedures for cable and pipeline crossings as well as adjacent media (emergency plans)	Crossings and adjacent media	very high
	c)	Planning that installation work is accompanied and checked by the MWS	Standstill Damage Possible effects on the design of insurance coverage	high
	f)	Cable logistics (loading of cable & transport)	Damage to cable Standstill Loss	high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.2
Analysis of known damage and early development and certification of appropriate procedures aiming at securing of the cable during any offshore repair work Provide for adequate resources	very good	4	medium risk	The aim shall be quick and persistent repair of potential damage Possible exchange of short lengths instead of repair Redundant park layouts reduce the effects of a defective cable	
Always submit procedures to the MWS on time to be checked against a previously stipulated standard and released by the MWS	adequate	6	medium risk	Experiences from many cable laying operations are bundled through the MWS to be used Consideration of the allowed sea and weather conditions during installation procedures	
Availability and implementation of execution planning Check execution planning for recency Suitable mounting equipment for planned execution Preparation of crossing structures Avoid "fly over" procedures (pulling devices over the structure) Highly-topical documentation within the scope of the laying accuracy laid down for the project	very good	4	medium risk	We urgently recommend an offshore co-ordinator / site co-ordinator for the project who shall promptly match the execution of different crafts	
Early co-ordination with MWS Installation work to be accompanied by the MWS who shall check it against a stipulated standard Recurring work can later be done without the MWS being present; this requires close co-ordination of the parties involved	adequate	6	medium risk	The MWS shall check and release any project-relevant procedure in advance	
Load in accordance with the "Cable Handling Guidelines" and loading procedures agreed upon Redundant communication between land and ship Observe how many times re-reeling may take place Match / synchronise turntables and linear machines Securing of cargo complies with international standards Cable inspections complies with test schedule agreed upon	adequate	6	medium risk	"Cable Handling Guidelines": ▪ Document to be supplied by the cable manufacturer how to handle the cable	

9.2

Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
f)	Cable installation in the wind field	Damage to cable Damage to equipment	very high
f)	Pulling cable into the wind turbine founda-tion and/or the wind turbine	Damage to cable	very high
f)	Pulling cable into the transformer platform	Damage to cable	very high
f)	Mechanical, electric, and fibre-optics termination	Damage to cable Damage to offshore structure	high
f)	Trenching	Insufficient bury depth Covering	very high
f)	Jetting	Damage to cable	very high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.2
Use a suitable installation software (e.g. WinFrog, Makai-Lay) to plan and control cable installation Make the laying parameters available to all ship stations (e.g. "Cable Handling Guidelines", laying angle, tractive force, etc.) Synchronise the cable machines, the speed of the installation equipment, and the ship speed	adequate	8	high risk	The installation software is designed to visualise and document any installation-relevant data (e.g. cable position, normally X, Y, and Z)	
Cable pull-in according to procedures agreed upon in consideration of the park layout Onshore trials of the pull-in procedure including cable protection system Permanent monitoring of pull-in forces Cable handling in compliance with the "Cable Handling Guidelines"	very good	4	medium risk	The 2nd pull-in operation is the most critical cable operation offshore This shall be taken into special consideration when selecting the installation equipment, establishing the procedures and the corresponding risk assessments	
Cable pull-in according to procedures agreed upon in consideration of the park layout Onshore trials of the pull-in procedure including cable protection system Permanent monitoring of pull-in forces Cable handling in compliance with the "Cable Handling Guidelines" Monitoring of cable on the seabed during the pull-in operation (e.g. observation with ROV) Take into account any adjacent cables under voltage	very good	4	medium risk	The 2nd pull-in operation is the most critical cable operation offshore This shall be taken into special consideration when selecting the installation equipment, establishing the procedures and the corresponding risk assessments	
Training and instruction of fitters in the field of connectors Thorough planning and development of a temporary as well as of a final hang-off (AdÜ?) according to the "Cable Handling Guidelines" Documentation of assembly work Selection of the corresponding tools for assembly and covering of critical components around (e.g. coating or cable) Thorough planning of any overlengths of cables to be pulled in as well as suitable fittings (e.g. transition sleeve)	very good	3	low risk	Provide for overlength reserve for new termination Offshore structures: ▪ Foundations ▪ Transformer substations ▪ Converter platforms ▪ Wind turbines etc.	
Use of appropriate installation equipment for submarine power cables Where required pre-trench the cable routes Planning and execution of more jetting in consideration of the reasonable endeavour	adequate	8	high risk		
	very good	4	medium risk	Where possible, cable installation without any external draw and shear force exerted on the cable	

9.2

Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
f)	Rock cutting	Damage to cable	very high
f)	Ploughing	Damage to cable	very high
f)	Additional protection measures (e.g. rock dumping, mattressing, URADUCTs, grout bags, etc.)	Damage to cable	high
g)	Cable inspection when connection finished	Damage to cable and connected fittings	small
h)	Cold commissioning	Damage to cable, fibre optic cable, and connected fittings (switchgear connector)	medium
h)	Hot commissioning	Damage to components in the entire electrical system (switchgear, transformer, cable, connector)	high

Legend
a) Execution planning of the soil investigation for the installation of cables in the wind farm
b) Soil investigation for the installation of cables in the wind farm
c) Execution planning of the transport (inland and offshore transport) and of the installation of the cables in the wind farm
d) Execution planning of the connection of the cables in the wind farm
e) Execution planning of the commissioning and the test run until getting the PAC
f) Transport (inland and offshore transport) and of the installation of the cables in the wind farm
g) Connections (installation) of the cables in the wind farm
h) Commissioning and test run until getting the PAC

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.2
	very good	4	medium risk	To date only the vertical injector and only a few trenching ROVs have reached a burial depth of more than 1.5 m for submarine power cables	
	poor	12	very high risk	Ploughing the cable into the seabed with existing equipment results in almost uncontrollable draw and shear forces, which can lead to destruction or premature ageing due to almost not detectable damage to the cables	
	adequate	6	medium risk	The use of a cable protection system also serves the protection of the cable from falling objects as well as rocks or perhaps mattresses	
	very good	1	low risk	Electricity and fibre-optics tests in combination with cold commissioning shall be carried out (e.g. insulation, VLF, OTDR)	
	very good	2	low risk	Electricity and fibre-optics tests in combination with cold commissioning shall be carried out (e.g. insulation, VLF, OTDR)	
	adequate	6	medium risk		

9.3 Engineering, transport of transformer station

9.3.1 Ships, barges, tugboats, etc.

9.3.1	Process steps	Short description of operation	Requirements for the operation	Marine Spread	Requirements	Risks
	Execution planning of offshore transports	Planning / assessment of necessary ships, barges, ... (proof of class)	Identification / calculation of the ship, tugboat, barge capacities required Tugging equipment (marine spread) based on industrial standards (DNV, GL Noble Denton, London Offshore, etc.)			Crane ships, tugboats, AHT, barges, supply vessels, jack-up barges / vessels etc., and equipment
	Execution planning of offshore transports	Planning / assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified require-ments Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews	Crane ship	Lifting capaci-ties Positioning conditions (DP, 4-point mooring) Navigation restrictions	
	Execution planning of offshore transports	Planning / assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified require-ments Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews	Tugboat	Static pull Machine output Operating radius Positioning conditions (DP, 4-point mooring) Navigation restrictions	

Events	Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.3.1
Inappropriate crane ships, tugboats, AHT, barges, supply vessels, jack-up barges / vessels etc., and equipment (as to project requirements or technical condition)	Failure of units used and corresponding delay for entire project	high risk	Select well-respected, experienced, and certi-fied shipping companies with crane ships, jack-up barges / vessels, tugboat and the corresponding managers (ISO, ISM, IMCA) Select appropriate vehicles, barges, etc. according to the corresponding project requirements Check the class documents and other certificates (e.g. equip-ment) Early draw up a condition survey of the units and equipment used to find adequate replacement where necessary Permanent supervision of the requirements for maritime units, e.g. weight	very good	3	low risk	

General remark:
- Determination of the most risky stage of travel
- Check of dimensions (length, width, draught) of the waterways to be passed (emergency ports, too)
- Undocking space (adverse effects on near sea lanes)
- Damage to towing equipment and connection, perhaps very long time in tow
- Availability of special ships very bad
- High daily rate and high technicization of the ship
- Issue of repair capacities and facilities
- Availability of spare parts and shipyard capacity
- Areas where the chartered ships may cruise and compliance with (inter)national conditions (operation, crew, classification)

1st scenario "floating platform"
- **H**ighest risk during undocking
- **L**ess tugboats required thereupon
- Tugboats shall feature corresponding static pull; this shall be available
- Fixture of towing equipment to the platform shall be calculated and welded on
- Classification Society and experience on tugboats
- Guidelines published in 2006 for the first time

2nd scenario "Transport of platform and base frame on barge"
- Check of capacities and availability of barges (alternatives: semisubmersible floating platform or floating dock)
- Costs for off-hire lay days when waiting for better weather
- Classification Society and equipment of barges (retrofitting for additional lashings with calculation of loading capacity), manoeuvrability (dynamic position, speed)

9.3.1	Process steps	Short description of operation	Requirements for the operation	Marine Spread	Requirements	Risks
	Execution planning of offshore transports	Planning / assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified require-ments Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews		Towing gear	
	Execution planning of offshore transports	Planning / assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified require-ments Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews	AHT	Anchor handling capacity Static pull Positioning conditions (DP, 4-point mooring) Navigation restrictions	
	Execution planning of offshore transports	Planning / assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified require-ments Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews	Barges	Navigation restrictions Dimensions Load bearing capacity Submergible	
	Execution planning of offshore transports	Planning / assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified require-ments Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews		Towing gear	

Events	Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.3.1

General remark:
- Determination of the most risky stage of travel
- Check of dimensions (length, width, draught) of the waterways to be passed (emergency ports, too)
- Undocking space (adverse effects on near sea lanes)
- Damage to towing equipment and connection, perhaps very long time in tow
- Availability of special ships very bad
- High daily rate and high technicization of the ship
- Issue of repair capacities and facilities
- Availability of spare parts and shipyard capacity
- Areas where the chartered ships may cruise and compliance with (inter)national conditions (operation, crew, classification)

1st scenario "floating platform"
- **H**ighest risk during undocking
- **L**ess tugboats required thereupon
- Tugboats shall feature corresponding static pull; this shall be available
- Fixture of towing equipment to the platform shall be calculated and welded on
- Classification Society and experience on tugboats
- Guidelines published in 2006 for the first time

2nd scenario "Transport of platform and base frame on barge"
- Check of capacities and availability of barges (alternatives: semisubmersible floating platform or floating dock)
- Costs for off-hire lay days when waiting for better weather
- Classification Society and equipment of barges (retrofitting for additional lashings with calculation of loading capacity), manoeuvrability (dynamic position, speed)

9.3.1	Process steps	Short description of operation	Requirements for the operation	Marine Spread	Requirements	Risks
	Execution planning of offshore transports	Planning / assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified require-ments Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews	Supply vessel	Deck surface area Deck capacities Crane capacity Tank capacities, e.g. navigation restrictions	
	Execution planning of offshore transports	Planning / assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified require-ments Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews	Jack-up barge / vessel	Operation - water depths Deck surface area Crane capacities Positioning conditions Accommodation Navigation restrictions	
	Execution planning of offshore transports	Planning / assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified require-ments Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews	Cable layer		

Events	Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.3.1

General remark:
- Determination of the most risky stage of travel
- Check of dimensions (length, width, draught) of the waterways to be passed (emergency ports, too)
- Undocking space (adverse effects on near sea lanes)
- Damage to towing equipment and connection, perhaps very long time in tow
- Availability of special ships very bad
- High daily rate and high technicization of the ship
- Issue of repair capacities and facilities
- Availability of spare parts and shipyard capacity
- Areas where the chartered ships may cruise and compliance with (inter)national conditions (operation, crew, classification)

1st scenario "floating platform"
- **H**ighest risk during undocking
- **L**ess tugboats required thereupon
- Tugboats shall feature corresponding static pull; this shall be available
- Fixture of towing equipment to the platform shall be calculated and welded on
- Classification Society and experience on tugboats
- Guidelines published in 2006 for the first time

2nd scenario "Transport of platform and base frame on barge"
- Check of capacities and availability of barges (alternatives: semisubmersible floating platform or floating dock)
- Costs for off-hire lay days when waiting for better weather
- Classification Society and equipment of barges (retrofitting for additional lashings with calculation of loading capacity), manoeuvrability (dynamic position, speed)

9.3 Engineering, transport of transformer station

9.3.2 Load-out

9.3.2	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
e)	Load-in/out	Identification of load-in/out objects		Weights Dimensions	Loaded object	Wrong weight information (no weight check during assembly) Wrong dimensions (no final object dimensons taken)
e)	Load-in/out	Identification of load-in/out method		Lift-on/off Slide-on/off Roll-on/off Float-in/off Skidding	Load-in/out method	Wrong load-in/out method selected
e)	Load-in/out	Identification of load-in/out equipment		Crane Trailer / SPMT Sliding system Skidding system Slings Upending tool Spreader beam Required class / certificate	Load-in/out equipment	Selection of improper load-in/out equipment because of wrong load-in/out method Selection of improper load-in/out equipment because of wrong weights and/or dimensions Non-compliance with requirements for class / certificates
e)	Load-in/out	Identification of appropriate port / water terminal		Access possibilities Mooring capacities Possibilities to manoeuvre Heavy cargo pier Storage capacities Position compared to installation site Jack-up possibilities in the port (soil conditions) Cargo handling capacities	Port / water terminal	Large transport distance between manufacturers Port of shipment / installation area Not enough moorings Poor manoeuvrability during loading, e.g. with floating crane Insufficient storage capacities Bad soil conditions to jack-up for corresponding barges / ships

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.2
Load-in/out impossible; thus, delayed load-in/ out as well as entire installation	medium risk	Weight monitoring Dimensions to be taken upon completion by certi-fied company Draught survey Make certifier / MWS verify this	adequate	4	medium risk		
Load-in/out impossible; thus, delayed load-in/ out as well as entire installation	medium risk	Verify basic design / detailed design Define appropriate load-in/out method Make certifier / MWS verify this	adequate	4	medium risk		
Load-in/out impossible; thus, delayed load-in/ out as well as entire installation	medium risk	Verify basic design / detailed design Define appropriate load-in/out equipment Select appropriate suppliers / check of/by (AdÜ?) suppliers Make certifier / MWS verify this	adequate	4	medium risk		
Load-in/out impossible; thus, delayed load-in/ out as well as entire installation	high risk	Thoroughly analyse / plan the requirements for the ports of loading/ unloading On-site inspection of the ports according to the requirements Early book by contracts the port capacities	very good	3	low risk		

9.3.2	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	e)	Load-in/out	Identification of the requirements for the load on the areas / piers for handling and storage	Surface load	Port, pier of loading/unloading, storage area	No use of port as not suitable for heavy cargo Damage to pier and access ways
	e)	Load-in/out	Identification of requirements for transport unit (barge, ship, tugboat, jack-up barge, etc.)	Loading capacity Deck surface area Stability Load on decks Ballasting Manoeuvrability	Barge Ship Jack-up barge etc.	Poor selection of transport unit due to wrong information on the object to be transported Invalid documents on class/certification Wrong and/or inappropriate manoeuvring properties
	k)	Load-in/out	Loading and ballasting	Stowing plan	Loading and ballasting	Wrong or poor loading / ballasting during load-in/out Malfunction of ballasting system Damage to ballasting system
	e)	Load-in/out	Verification of class documents / certificates regarding project requirements		Barge Ship Jack-up barge etc.	No valid class documents / certificates
	k)	Load-in/out	Verification of class documents / certificates regarding project requirements		Barge Ship Jack-up barge etc.	No valid class documents / certificates

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.2
Load-in/out impossible; thus, delayed load-in/ out as well as entire installation	high risk	Thoroughly analyse / plan the requirements for the ports and piers of loading/unloading, access ways On-site inspection of the ports according to the requirements	very good	3	low risk		
Use of transport units impossible Damage to transport unit and cargo Capsizing of transport unit due to insufficient stability and/or poor sequences of ballasting / dropping ballast Entire project delayed	medium risk	Thoroughly analyse / plan the loading and transport sections Thoroughly analyse the requirements for the ports of loading/unloa-ding Thoroughly plan the loading and transport units Prepare loading plans / method statements for each load-in/out	adequate	4	medium risk		
Transport unit will capsize Damage to transport unit and object Damage to fix and floating objects and environment Load-in/out impossible and/or entire project delayed	very high risk	Draw up a stowage and ballast plan for load-in/ out - process / sequen-ces Check and test the ballasting system prior to load-in/out Monitor the loading and ballasting sequences	very good	4	medium risk		
Loading in/out impos-sible Thus, loading in/out and entire project delayed	medium risk	Verify the class documents / certificates prior to any use of the units Ensure that the class documents / certificates will be valid for the entire mission or apply for new ones	adequate	4	medium risk		
Loading in/out impos-sible Thus, loading in/out and entire project delayed	medium risk	Verify the class documents / certificates prior to any use of the units Ensure that the class documents / certificates will be valid for the entire mission or apply for new ones	adequate	4	medium risk		

9.3.2	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	e)	Load-in/out	Verification of class documents / certificates regarding the personnel	Crane driver Trainers / marshalling personnel (AdÜ? oder einweisen im Sinne von Platz zuweisen?) Operating personnel Maritime crews	Personnel	Insufficient experience how to carry out loading/ unloading processes - heavy lift / offshore Lack of / insufficient communication during loading / unloading
	k)	Load-in/out	Verification of class documents / certificates regarding the personnel	Crane driver Trainers / marshalling personnel (AdÜ? oder einweisen im Sinne von Platz zuweisen?) Operating personnel Maritime crews	Personnel	Insufficient experience how to carry out loading/ unloading processes, heavy lift / offshore Lack of / insufficient communication during loading / unloading
	k)	Load-in/out	Permanent observation / verification of the weather conditions		Weather and sea state conditions	Heavy wind, gusts Sea too rough Tide

Legend
a) Execution planning of the soil investigation for the site of the offshore transformer station in the wind farm
b) Soil investigation for the site of the offshore transformer station in the wind farm
c) Execution planning of the inland transport (overland and rivers) from the factory to the offshore port
d) Execution planning of the storage in the offshore port and the onshore assembly there
e) Execution planning of offshore transports
f) Execution planning of offshore erection
g) Execution planning of residual assembly work offshore
e) Execution planning of the commissioning and the test run until getting the PAC
i) Inland transport (overland and rivers) from the factory to the offshore port
j) Storage in the offshore port and the onshore assembly there
k) Offshore transports
l) Offshore erection
m) Residual assembly work offshore
n) Commissioning and test run until getting the PAC

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.2
Transport unit will capsize Damage to transport unit and object Damage to fixed or floating objects and environment, e.g. pier Load-in/out impossible and/or entire project delayed	high risk	Verify qualification and experience of the person-nel for crane and AdÜ s.o. Draw up a loading plan with responsibilities / communication Kick-off meeting with the persons in charge for the project Toolbox meetings prior to load-in/out	very good	3	low risk		
Transport unit will capsize Damage to transport unit and object Damage to fixed or floating objects and environment, e.g. pier Load-in/out impossible and/or entire project delayed	high risk	Verify qualification and experience of the person-nel for crane and AdÜ s.o. Draw up a loading plan with responsibilities / communication Kick-off meeting with the persons in charge for the project Toolbox meeting prior to load-in/out	very good	3	low risk		
Loading / unloading impossible due to the weather criteria Loading / unloading delayed Loss of cargo and/or damage to cargo Entire project delayed	high risk	Check wether the weather reports meet the weather criteria Toolbox meeting with all persons involved in the process before starting the corresponding process step; talk about stop criteria Monitor present weather conditions	adequate	6	medium risk		

9.3 Engineering, transport of transformer station

9.3.3 Transport on own hull

9.3.3	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore transports	Transport on own hull	Towability	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	Floatability of the topside	Topside will capsize and/ or sink

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.3
Damage to the topside and the equipment installed or loss of topside Entire project delayed Damage to fix and floating objects and environment	very high risk	Calculate floatability, stability, trim - according to international rules and regulation (e.g. MODU code) Calculate the max. values for acceleration and heeling and check against the permitted values Make certifier / MWS verify this Monitor the current acceleration and heeling values during transport and installation Carry out towing tests in the towing tank / simulations	adequate	8	high risk	**General:** ▪ Floating device and towing gear of platform ▪ Towing approval **1st scenario "out of the dock":** ▪ Damage to dock, tugboat, or third-party property ▪ Adverse effect on adjacent sea lanes ▪ Personal injury and environmental damage ▪ Physical damage to the substance of the platform, perhaps disposal of wreck ▪ Calculation and approval of towing gears ▪ Damage to towing connection (prepared emergency connec-tion) ▪ Lighting **2nd scenario "on the base frame":** ▪ Delay due to weather ▪ Additional tugboats as support ▪ Problems with assembly	

9.3.3	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore transports	Transport on own hull	Towability	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	Water tightness of the topside	Water inrush, topside will capsize and/or sink

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.3
Damage to the topside and the equipment installed or loss of topside Entire project delayed Damage to fix and floating objects and environment	high risk	Draw up a plan to establish water tight-ness: ▪ Determine number of openings ▪ Define method to establish water tight-ness ▪ Test procedure ▪ Verify ▪ water tightness during transport / installati-on by floaters (alarm equipment), draught marks on topside ▪ Install crew on topside (if required) and stand watch ▪ Install pump system if water enters into the topside Establish and test water alarm and pump systems Make MWS effect an acceptance inspection of the platform by MWS upon establishment of water tightness / seal Monitor for water inrush into the topside, alarm system / watches	very good	3	low risk	**General:** ▪ Floating device and towing gear of platform ▪ Towing approval **1st scenario "out of the dock":** ▪ Damage to dock, tugboat, or third-party property ▪ Adverse effect on adjacent sea lanes ▪ Personal injury and environmental damage ▪ Physical damage to the substance of the platform, perhaps disposal of wreck ▪ Calculation and approval of towing gears ▪ Damage to towing connection (prepared emergency connec-tion) ▪ Lighting **2nd scenario "on the base frame":** ▪ Delay due to weather ▪ Additional tugboats as support ▪ Problems with assembly	

9.3.3	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore transports	Transport on own hull	Towability	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	Towability of topside	Resistance to towing too high Towing speed too slow Poor towing behaviour (e.g. swinging)
	Offshore transports	Transport on own hull	Towability	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	"Strong points"	Improper "strong points"

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.3
The required towing speed is not reached; therefore, towing actually impossible Poor towing behavi-our (e.g. too much swinging) makes towing impossible Entire project delayed	high risk	Calculate towing behavi-our in theory Carry out towing tests in the towing tank Re-design if required Calculate required towing capacities	adequate	6	medium risk	**General:** ▪ Floating device and towing gear of platform ▪ Towing approval **1st scenario "out of the dock":** ▪ Damage to dock, tugboat, or third-party property ▪ Adverse effect on adjacent sea lanes ▪ Personal injury and environmental damage ▪ Physical damage to the substance of the platform, perhaps disposal of wreck ▪ Calculation and approval of towing gears ▪ Damage to towing connection (prepared emergency connec-tion) ▪ Lighting **2nd scenario "on the base frame":** ▪ Delay due to weather ▪ Additional tugboats as support ▪ Problems with assembly	
As the "strong points" are improper, towing and/or positioning of the topside is impos-sible Drifting off, grounding, collision, capsizing, or loss possible Damage to topside Water inrush Entire project delayed	high risk	Based on the calculations of the required towing capacities, the strong points are designed according to applicable standards (DNV, GL ND) Requirements and number of strong points are designed according to the use (towing, mooring, positioning) Correspondingly mark the "strong points" Position and SWL	very good	3	low risk		

9.3.3	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore transports	Transport on own hull	Towability	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	"Push" zones	Improper "push zones"
	Offshore transports	Transport on own hull	Towage	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	Route	Inappropriate route Ports of refuge Protected areas due to limited navigational towing possibilities (AdÜ: INhalt?) (draughts, widths of canals, narrows, lengths of locks, overhead clearances under bridges)

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.3
As the "push zones" are improper, towing and/ or positioning of the topside is impossible Drifting off, grounding, collision, capsizing, or loss possible Damage to topside Water inrush Entire project delayed	high risk	Requirements and number of "push zones" are designed according to the use (towing, mooring, positioning) Correspondingly mark the "push zones" on the top side (position and SWL) so that the tugboats know where and at which level they have to push	very good	3	low risk	**General:** ▪ Floating device and towing gear of platform ▪ Towing approval **1st scenario "out of the dock":** ▪ Damage to dock, tugboat, or third-party property ▪ Adverse effect on adjacent sea lanes ▪ Personal injury and environmental damage ▪ Physical damage to the substance of the platform, perhaps disposal of wreck ▪ Calculation and approval of towing gears ▪ Damage to towing connection (prepared emergency connec-tion) ▪ Lighting **2nd scenario "on the base frame":** ▪ Delay due to weather ▪ Additional tugboats as support ▪ Problems with assembly	
Towing impossible or longer towing route (distance, time) Entire project delayed	very high risk	Check the navigational towability of the objects to be transporteds and use of the planned towing/lifting capaci-ties prior to opting for a shipyard (draughts, widths of canals, narrows, lengths of locks, overhead clearances under bridges, interna-tional and national rules and regulations, etc.) Plan exact route, protection areas, ports of refuge, use of canals in compliance with national and international rules and regulations	very good	4	medium risk		

9.3.3	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore transports	Transport on own hull	Towage	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	Tugboat	Damage to tugboat
	Offshore transports	Transport on own hull	Towage	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	Tugboat	Collision with other ships or other fixed or floating objects

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.3
No tugboat, drifting off, grounding, collision, capsizing, sinking, or loss possible Tugboat to be replaced Towage and entire project delayed	medium risk	Select well-respected, experienced, and certi-fied shipping companies (ISO, ISM, IMCA) Early draw up a condition survey of the units and equipment used to find adequate replacement when necessary Permanently monitor towing / installation by means of a tow master (AdÜ: Mensch oder Gerät?) Contingency plan for lack of tugboats (ISM) Access to stand-by tugboats	very good	2	low risk	**General:** ▪ Floating device and towing gear of platform ▪ Towing approval **1st scenario "out of the dock":** ▪ Damage to dock, tugboat, or third-party property ▪ Adverse effect on adjacent sea lanes ▪ Personal injury and environmental damage ▪ Physical damage to the substance of the platform, perhaps disposal of wreck ▪ Calculation and approval of towing gears ▪ Damage to towing connection (prepared emergency connec-tion) ▪ Lighting **2nd scenario "on the base frame":** ▪ Delay due to weather ▪ Additional tugboats as support ▪ Problems with assembly	
Structural damage to tugboat Water inrush, capsi-zing, sinking, or loss of tugboat Damage to fix and floating objects and environment Towage and entire project delayed	medium risk	Plan and supervise exact route Comply with COLREGs (e.g. day and night signals for towing trains) Use a guard-boat Warn other ships of exceptional towing train Emergency plans Access to stand-by tugboats	very good	2	low risk		

9.3.3	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore transports	Transport on own hull	Towage	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	Tugboat	Taking the ground
	Offshore transports	Transport on own hull	Towage	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	Tugboat	Fire

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.3
Water inrush, capsi-zing, sinking, or loss of tugboat Damage to tugboat Damage to fix and floating objects and environment Towage and entire project delayed	medium risk	Plan and supervise exact route Emergency plan and emergency measures according to SMS / ISM If required, transfer of the mission to other tugboats	very good	2	low risk	**General:** ▪ Floating device and towing gear of platform ▪ Towing approval **1st scenario "out of the dock":** ▪ Damage to dock, tugboat, or third-party property ▪ Adverse effect on adjacent sea lanes ▪ Personal injury and environmental damage ▪ Physical damage to the substance of the platform, perhaps disposal of wreck ▪ Calculation and approval of towing gears ▪ Damage to towing connection (prepared emergency connec-tion) ▪ Lighting **2nd scenario "on the base frame":** ▪ Delay due to weather ▪ Additional tugboats as support ▪ Problems with assembly	
Structural damage to tugboat Water inrush, capsi-zing, sinking, or loss of tugboat Damage to fix and floating objects and environment Towage and entire project delayed	medium risk	Structural and mobile fire alarm and fire extinguishing systems according to SOLAS Permanent monitoring of the fire alarm systems Emergency plans accor-ding to SMS / ISM	very good	2	low risk		

9.3.3	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore transports	Transport on own hull	Towage	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	Towrope	Towrope damaged / broken
	Offshore transports	Transport on own hull	Towage	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	Barge/ topside	Collision with other ships or other fixed or floating objects

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.3
Drifting off, grounding, capsizing, sinking, or loss of topside possible Damage to fix and floating objects and environment Towage and entire project delayed	medium risk	Use adequate towrope according to correspon-ding standards (DNV, GL ND) on the basis of the calculated capacities to be towed Redundant towing equip-ment	very good	2	low risk	**General:** ▪ Floating device and towing gear of platform ▪ Towing approval **1st scenario "out of the dock":** ▪ Damage to dock, tugboat, or third-party property ▪ Adverse effect on adjacent sea lanes ▪ Personal injury and environmental damage ▪ Physical damage to the substance of the platform, perhaps disposal of wreck ▪ Calculation and approval of towing gears ▪ Damage to towing connection (prepared emergency connec-tion) ▪ Lighting **2nd scenario "on the base frame":** ▪ Delay due to weather ▪ Additional tugboats as support ▪ Problems with assembly	
Capsizing, sinking, or loss of barge / topside possible Heavy damage to topside Damage to fix and floating objects and environment Towage and entire project delayed	very high risk	Plan and supervise exact route Comply with COLREGs (e.g. day and night signals for towing trains) Use a guard-boat Warn other ships of exceptional towing train Emergency plans	very good	4	medium risk		

9.3.3	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore transports	Transport on own hull	Towage	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	Barge/ topside	Taking the ground
	Offshore transports	Transport on own hull	Towage	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	Barge/ topside	Fire

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.3
Capsizing, sinking, or loss of barge / topside possible Heavy damage to tugboat Damage to fix and floating objects and environment	medium risk	Plan and supervise exact route Emergency plan and emergency measures according to SMS / ISM Secure the tugboat Lighter the barge or topside, respectively, if possible	very good	2	low risk	**General:** ▪ Floating device and towing gear of platform ▪ Towing approval **1st scenario "out of the dock":** ▪ Damage to dock, tugboat, or third-party property ▪ Adverse effect on adjacent sea lanes ▪ Personal injury and environmental damage ▪ Physical damage to the substance of the platform, perhaps disposal of wreck ▪ Calculation and approval of towing gears ▪ Damage to towing connection (prepared emergency connec-tion) ▪ Lighting **2nd scenario "on the base frame":** ▪ Delay due to weather ▪ Additional tugboats as support ▪ Problems with assembly	
Structural damage to barge / topside Capsizing, sinking, or loss of barge / topside possible Damage to fix and floating objects and environment	medium risk	Structural and mobile fire alarm and fire extin-guishing systems Permanent monitoring of the fire alarm systems Emergency plans accor-ding to SMS / ISM	very good	2	low risk		

9.3.3	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore transports	Transport on own hull	Towage	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	Barge/ topside (towage on proper keel)	Damage Towing gear broken
	Offshore transports	Transport on own hull	Towage	Floatability - stability / trim Max. acceleration Max. angle of heeling Water tightness Towing behaviour (speed, resistance, following properties) Towing gear / equipment (strong points) "Push" zones: ▪ Route ▪ Tugboat ▪ Barge ▪ Topside ▪ Weather criteria	Weather conditions	Adverse weather conditions

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.3
Drifting off, grounding, capsizing, sinking, or loss of barge / topside possible Damage to fix and floating objects and environment Towage and entire project delayed	medium risk	Use adequate towing gear according to corre-sponding standards (DNV, GL ND) on the basis of the calculated capacities to be towed Install redundant towing gear (emergency gear)	very good	2	low risk	**General:** ▪ Floating device and towing gear of platform ▪ Towing approval **1st scenario "out of the dock":** ▪ Damage to dock, tugboat, or third-party property ▪ Adverse effect on adjacent sea lanes ▪ Personal injury and environmental damage ▪ Physical damage to the substance of the platform, perhaps disposal of wreck ▪ Calculation and approval of towing gears ▪ Damage to towing connection (prepared emergency connec-tion) ▪ Lighting **2nd scenario "on the base frame":** ▪ Delay due to weather ▪ Additional tugboats as support ▪ Problems with assembly	
Damage to tugboat, barge, topside Towage and entire project delayed	very high risk	Definition of the weather criteria based on the design of the topside (design, equipment, max. values for acceleration / heeling, sea-fastening, etc.) Check wether the weather reports meet the weather criteria Monitor present weather conditions	very good	4	medium risk		

9.3 Engineering, transport of transformer station

9.3.4 Route, ports of refuge, and refuges in general

9.3.4	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Execution planning of offshore transports	Planning of the route, ports of refuge, and protection areas	Identification of appropriate routes for towing	Navigation restrictions due to length, width, draught, and overhead clearances of the towing object and the object to be towed in locks, canals, narrows, under bridges, etc. International and national rules and regulations for shipping	Route (ports of refuge and protection areas)	Inappropriate route, ports of refuge, protected areas due to limited navigational towing possibilities (draughts, widths of canals, narrows, lengths of locks, overhead clearances under bridges)
	Execution planning of offshore transports and offshore erection	Planning of the route, ports of refuge, and protection areas	Definition of weather criteria for transport and installation	Definition of weather, sea state, and flow criteria to provide for safe transport and installation on the basis of weather, sea state, and flow statistics for the respective area of transportation and installation	Weather Flows Sea state Tides	Area of installation cannot be reached and/ or project delayed

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.3.4
Towing impossible or longer towing route (distance, time) Towage and entire project delayed	high risk	Exactly plan where the platform is to be erected on the basis of the towability from the shipyard to the installation area. Exactly plan the routes on the basis of: ▪ the given dimensions of the towing units and those to be towed ▪ the applicable national and international regulations and laws	very good	3	low risk	
Project infeasible Towing and/or installation delayed Damage to towed object	high risk	Define realistic weather criteria for towing, the area where towing will take place, and the time when towing will take place Check wether the weather reports meet the weather criteria Monitor present weather conditions	adequate	6	medium risk	

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9.3.5 Sea-fastening, grillage, structure

9.3.5	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Execution planning of offshore transports	Sea-fastening and grillage Deck structure integrity	Planning and calculation of sea-fastening	Object to be transported Transport equipment Lashing methods / system Loads on deck Strong points / attachment points	Sea-fastening	Wrong or poor sea-fastening Safe releasing of the sea-fastening impossible when being offshore Wrong releasing of sea-fastening Damage to lashing equipment used Failure of sea-fastening
	Execution planning of offshore transports	Sea-fastening and grillage Deck structure integrity	Planning and calculation of grillage	Object to be transported Transport equipment Lashing methods / system Loads on deck Strong points / attachment points	Grillage	Damage to installed grillage Failure of grillage
	Execution planning of offshore transports	Sea-fastening and grillage Deck structure integrity	Planning and calculation of deck structure integrity	Object to be transported Transport equipment Lashing methods / system Loads on deck Strong points / attachment points	Deck structure integrity	Damage to deck structure Failure of deck structure

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.5
Damage to cargo and transport means Loss of cargo or splitting of cargo and transport means Damage to fix and floating objects and environment Transport unit will capsize Towage and entire project delayed	high risk	Plan and calculate the sea-fastening on the basis of the weather conditions defined for the object to be trans-ported and the transport equipment Implement the planning in construction Supervise the execution of construction work Prepare method state-ments to establish / release sea-fastening Make MWS verify and approve this	very good	3	low risk	Evidence of allowed load on decks for barges (deck slab size, size of longitudinal structures and trans-verse structures, shell, tanks, bollards, etc.) Evidence of additional lashings as required by regulations (quantity, position) Condition, approval, certification of lashing material	
Damage to cargo and transport means Loss of cargo / trans-port means Damage to fix and floating objects and environment Towage and entire project delayed	high risk	Plan and calculate the grillage on the basis of the weather conditions defined for the object to be transported and the transport equipment Implement the planning in construction Make MWS verify and approve this	very good	3	low risk		
Damage to cargo and transport means Loss of cargo / trans-port means Damage to fix and floating objects and environment Towage and entire project delayed	very high risk	Evidence of allowed loads on deck, structures, lashing points accor-ding to SOLAS (Cargo Securing Manual) Proof by calculation of the loads resulting from cargo, grillage, and sea-fastening Verification and approval on site by MWS	very good	4	medium risk		

9.3 Engineering, transport of transformer station

9.3.6 MWS weather criteria

9.3.6	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore transports	Clearing up allowed sea state and weather conditions with MWS / certifier	Structural design and implementation of requirements for objects to be transported and sea-fastening on the basis of defined sea state and weather conditions	Weather conditions	Design faults Faults when installing the transport equipment onto the object to be transported
	Execution planning of offshore erection	Clearing up allowed sea state and weather conditions with MWS / certifier	Structural design and implementation of requirements for objects to be transported and sea-fastening on the basis of defined sea state and weather conditions	Weather conditions	Design faults Faults when installing the installation equipment (AdÜ: Was ist damit gemeint?) onto the object to be transported
	Execution planning of offshore transports	Clearing up allowed sea state and weather conditions with MWS / certifier	Planning of different transport sections	Weather conditions	Wrong verification of transport sections
	Execution planning of offshore erection	Clearing up allowed sea state and weather conditions with MWS / certifier	Planning of different installation stages	Weather conditions	Wrong verification of the installation stages
	Execution planning of offshore transports	Clearing up allowed sea state and weather conditions with MWS / certifier	Definition of weather, sea state, and flow criteria to provide for safe transport on the basis of weather, sea state, and flow statistics for the respective area of transportation	Weather conditions	Wrong basis of statistical data for the area and period of transportation

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.3.6
Wrong definition of maximum weather and sea state criteria Damage to topside and other objects to be transported Damage to fix and floating objects and environment Transport and/or lifting opera-tions and entire project delayed	high risk	Define the design requirements by exact planning of the transport sections Make MWS verify this	very good	3	low risk	
Wrong definition of maximum weather and sea state criteria Damage to topside and other objects to be transported Damage to fix and floating objects and environment Transport and/or lifting opera-tions and entire project delayed	high risk	Define the design requirements by exact planning of the installation stages Make MWS verify this	very good	3	low risk	
Wrong definition of maximum weather and sea state criteria Damage to topside and other objects to be transported Damage to fix and floating objects and environment Transport and/or lifting opera-tions and entire project delayed	high risk	Exactly plan the individual transport sections Make certifier / MWS verify this	very good	3	low risk	
Wrong definition of maximum weather and sea state criteria Damage to topside and other objects to be transported Damage to fix and floating objects and environment Transport and/or lifting opera-tions and entire project delayed	high risk	Exactly plan the individual transport stages Make certifier / MWS verify this	very good	3	low risk	
Wrong definition of maximum weather and sea state criteria Damage to topside and other objects to be transported Damage to fix and floating objects and environment Transport and/or lifting opera-tions and entire project delayed	high risk	Select the relevant statistical data on the basis of an exact plan of the area of operation Make certifier / MWS verify this	very good	3	low risk	

9.3.6	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore erection	Clearing up allowed sea state and weather conditions with MWS / certifier	Definition of weather, sea state, and flow criteria to provide for safe installation on the basis of weather, sea state, and flow statistics for the respective area of installation	Weather conditions	Wrong basis of statistical data for the area and period of installation

Definition of weather, sea state, and flow criteria to provide for safe transport and installation on the basis of weather, sea state, and flow statistics for the respective area of transportation and installation

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.3.6
Wrong definition of maximum weather and sea state criteria Damage to topside and other objects to be transported Damage to fix and floating objects and environment Transport and/or lifting opera-tions and entire project delayed	high risk	Select the relevant statistical data on the basis of an exact plan of the area of operation Make certifier / MWS verify this	very good	3	low risk	

9.3 Engineering, transport of transformer station

9.3.7 Operating manual complies with limitations

9.3.7	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore transports	Operating manual complies with limitations	Preparing operating manuals / method statements	Method statements Operating manuals	Wrong / poor information about restrictions for transport (e.g. weight, acceleration, weather and sea state criteria)
	Execution planning of offshore erection	Operating manual complies with limitations	Preparing operating manuals / method statements	Method statements Operating manuals	Wrong / poor information about restrictions for installation (e.g. weight, acceleration, weather and sea state criteria)

Consequences	Risk assessment	Protection measure	Assessment of protection measures	Relevance	Status	9.3.7
Wrong reproduction of restrictions leads to transmission of wrong information to the transport contractors / sub-contractors This entails damage or loss of the object to be transported and the transport and/or installation equipment, damage to fix and floating objects, and environmental damage	high risk	Peruse and verify the operating manuals / method statements following the six-eyes principle Discuss and verify the restriction criteria with the transport contractors / sub-contractors Make certifier / MWS verify this	very good	3	low risk	
Wrong reproduction of restrictions leads to transmission of wrong information to the installation contractors / sub-contractors This entails damage or loss of the object to be installed and the installation equipment, damage to fix and floating objects, and environmental damage	high risk	Peruse and verify the operating manuals / method statements following the six-eyes principle Discuss and verify the restriction criteria with the installation contractors / sub-contractors Make certifier / MWS verify this	very good	3	low risk	

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9.3.8 Availability of MWS

9.3.8	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore transports	Clear up whether MWS will be available during transport	Verification of MWS availability during transport	MWS	No MWS available No MWS available who is familiar with this transport section
	Execution planning of offshore erection	Clearing up whether MWS will be available during offshore installation	Verification of MWS availability during installation	MWS	No MWS available No MWS available who is familiar with this installation stage

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.8
No general approval / approval of the individu-al transport section Execution of the indivi-dual transport sections delayed Loss of weather slot for this transport section	medium risk	Contact insurance companies to ask for recommended MWS companies Check 24/7-availability of MWS prior to entering into an agreement Verify references as to sufficient experience during approval / general approval of the transport section in question	very good	2	low risk	Limited number of MWS skilled in this field In case of delays perhaps not available anymore	
No general approval / approval of the individu-al installation stage Execution of the indivi-dual installation stages delayed Loss of weather slot for this installation stage	medium risk	Contact insurance companies to ask for recommended MWS companies Check 24/7-availability of MWS prior to entering into an agreement Verify references as to sufficient experience during approval / general approval of the installation stages in question	very good	2	low risk		

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9.3.9 Emergency plans - person in charge

9.3.9	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore transports	Draw up emergency plans Designation of responsible persons in consideration of the German Construction Site Ordinance (AdÜ: hier ist das deutsche Gesetz gemeint?)	Execution of HAZID / HAZOP	HAZID / HAZOP	No HAZID / HAZOP take place Process- and/or design-relevant dangers not recognised
	Execution planning of offshore erection	Draw up emergency plans Designation of responsible persons in consideration of the German Construction Site Ordinance (AdÜ: hier ist das deutsche Gesetz gemeint?)	Execution of HAZID / HAZOP	HAZID / HAZOP	No HAZID / HAZOP take place Process- and/or design-relevant dangers not recognised
	Execution planning of offshore transports	Draw up emergency plans Designation of responsible persons in consideration of the German Construction Site Ordinance (AdÜ: hier ist das deutsche Gesetz gemeint?)	Execution of risk assessment	Risk assessment	No risk assessment take place Risks are not detected and/or not analysed or wrongly assessed
	Execution planning of offshore erection	Draw up emergency plans Designation of responsible persons in consideration of the German Construction Site Ordinance (AdÜ: hier ist das deutsche Gesetz gemeint?)	Execution of risk assessment	Risk assessment	No risk assessment takes place Risks are not detected and/or not analysed or wrongly assessed
	Execution planning of offshore transports	Draw up emergency plans Designation of responsible persons in consideration of the German Construction Site Ordinance (AdÜ: hier ist das deutsche Gesetz gemeint?)	Drawing up emergency plans for all transport sections	Emergency plan	No or insufficient emergency plans drawn up

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.3.9
Cargo / transport equipment, process execution, and the personnel involved at risk Damage to the cargo of equip-ment used (AdÜ: oder "und der eingesetzten Ausrüstung"? Transportation impossible	high risk	Execution of HAZID / HAZOP Comply with national standards and requirements Analyse the risks and if required change the process and/or the design	very good	3	low risk	
Cargo / transport equipment, process execution, and the personnel involved at risk Damage to the cargo of equip-ment used (AdÜ: oder "und der eingesetzten Ausrüstung"? Installation impossible	high risk	Execution of HAZID / HAZOP Comply with national standards and requirements Analyse the risks and if required change the process and/or the design	very good	3	low risk	
No conclusions to avoid risks / hazards Consequence: damage and accidents	high risk	Establish risk assessment for all trans-port procedures Identify correction and/or protection measures Implement correction and/or protection measures into the design, method state-ments, process sequences, QHSE proce-dures, training programmes, instructions for PPE, emergency concepts, etc. Complement / draw up a register of risks	very good	3	low risk	
No conclusions to avoid risks / hazards Consequence: damage and accidents	high risk	Establish risk assessment for all installa-tion procedures Identify correction and/or protection measures Implement correction and/or protection measures into the design, method state-ments, process sequences, QHSE proce-dures, training programmes, instructions for PPE, emergency concepts, etc. Complement / draw up a register of risks	very good	3	low risk	
As risk assessment is missing, hazards, risks, and any conse-quences are not detected and, therefore, no emergency measures are planned to be taken should the case occur Insufficient preparation for the handling / averting of hazardous situations	high risk	Prepare emergency plans for all transport procedures on the basis of the HAZID, HAZOP, and risk assessments carried out	very good	3	low risk	

9.3.9

Process steps	Short description of operation	Requirements for the operation	Risks	Events
Execution planning of offshore erection	Draw up emergency plans Designation of responsible persons in consideration of the German Construction Site Ordinance (AdÜ: hier ist das deutsche Gesetz gemeint?)	Drawing up emergency plans for all installation stages	Emergency plan	No or insufficient emergency plans drawn up
Execution planning of offshore transports	Draw up emergency plans Designation of responsible persons in consideration of the German Construction Site Ordinance (AdÜ: hier ist das deutsche Gesetz gemeint?)	Execution of emergency practices	Emergency practices	No or insufficient training and emergency practices
Execution planning of offshore erection	Draw up emergency plans Designation of responsible persons in consideration of the German Construction Site Ordinance (AdÜ: hier ist das deutsche Gesetz gemeint?)	Execution of emergency practices	Emergency practices	No or insufficient training and emergency practices
Execution planning of offshore transports	Draw up emergency plans Designation of responsible persons in consideration of the German Construction Site Ordinance (AdÜ: hier ist das deutsche Gesetz gemeint?)	Definition of responsibilities and alerting methods and/or channels of communication	Emergency response team	Responsibilities, alerting methods, and channels of communication insufficient or not defined at all
Execution planning of offshore erection	Draw up emergency plans Designation of responsible persons in consideration of the German Construction Site Ordinance (AdÜ: hier ist das deutsche Gesetz gemeint?)	Definition of responsibilities and alerting methods and/or channels of communication	Emergency response team	Responsibilities, alerting methods, and channels of communication insufficient or not defined at all

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.3.9
As risk assessment is missing, hazards, risks, and any conse-quences are not detected and, therefore, no emergency measures are planned to be taken should the case occur Insufficient preparation for the handling / averting of hazardous situations	high risk	Prepare emergency plans for all installa-tion procedures on the basis of the HAZID, HAZOP, and risk assessments carried out	very good	3	low risk	
Insufficient preparation and training for potential cases of emergency Staff and crews cannot cope with the situation	high risk	Prepare training plans on the basis of the emergency plans Carry out training and emergency practices on the basis of the training plans to be prepared for the case of emergency	very good	3	low risk	
Insufficient preparation and training for potential cases of emergency Staff and crews cannot cope with the situation	high risk	Prepare training plans on the basis of the emergency plans Carry out training and emergency practices on the basis of the training plans to be prepared for the case of emergency	very good	3	low risk	
Missing or insufficient decision structures Missing or insufficient informati-on management Chaotic and/or insufficient co-ordination of emergency measures	high risk	Provide for competent specialists for the different processes Prepare training plans on the basis of the emergency plans Carry out training and emergency practices on the basis of the training plans to be prepared for the case of emergency Carry out table-top training Communication channels tested	very good	3	low risk	
Missing or insufficient decision structures Missing or insufficient informati-on management Chaotic and/or insufficient co-ordination of emergency measures	high risk	Provide for competent specialists for the different processes Prepare training plans on the basis of the emergency plans Carry out training and emergency practices on the basis of the training plans to be prepared for the case of emergency Carry out table-top training Communication channels tested	very good	3	low risk	

9.3 Engineering, transport of transformer station

9.3.10 Component of limited tipping angle

9.3.10	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore transports	Registration of components of limited tipping angle	Checking all components for a limit of heeling/tipping angle	Tipping angle	Insufficient information about permitted angle of heeling/tipping
	Execution planning of offshore erection	Registration of components of limited tipping angle	Checking all components for a limit of heeling/tipping angle	Tipping angle	Insufficient information about permitted angle of heeling/tipping
	Offshore transports	Registration of components of limited tipping angle	Checking all components for a limit of heeling/tipping angle	Tipping angle	Exceeding of angle of heeling/tipping
	Offshore erection	Registration of components of limited tipping angle	Checking all components for a limit of heeling/tipping angle	Tipping angle	Exceeding of angle of heeling/tipping

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.10
Damage to and/or loss of object to be transported / transport equipment Damage to fix and floating objects and environment	high risk	Check all components of the object to be trans-ported for max. angle of heeling/tipping Calculate max. allowed weather/sea state condi-tions for max. allowed angle of heeling/tipping	very good	3	low risk	Susceptibility of components' heeling to waves and wind Enlarged surface exposed to the wind Vibrations	
Damage to and/or loss of object to be transported / transport equipment Damage to fix and floating objects and environment	high risk	Check all components of the object to be trans-ported for max. angle of heeling/tipping Calculate max. allowed weather/sea state condi-tions for max. allowed angle of heeling/tipping	very good	3	low risk		
Damage to and/or loss of object to be transported / transport equipment Damage to fix and floating objects and environment	high risk	Observe the weather criteria for transport and installation Monitor the angle of heeling/tipping by means of appropriate measuring and recording instru-ments during transport and installation	very good	3	low risk		
Damage to and/or loss of object to be transported / transport equipment Damage to fix and floating objects and environment	high risk	Observe the weather criteria for transport and installation Monitor the angle of heeling/tipping by means of appropriate measuring and recording instru-ments during transport and installation	very good	3	low risk		

9.3 Engineering, transport of transformer station

9.3.11 Component of limited acceleration

9.3.11	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore transports	Registration of components of limited acceleration	Checking all components for a limit of acceleration	Acceleration	Insufficient information about permitted acceleration values
	Execution planning of offshore erection	Registration of components of limited acceleration	Checking all components for a limit of acceleration	Acceleration	Insufficient information about permitted acceleration values
	Offshore transports	Registration of components of limited acceleration	Checking all components for a limit of acceleration	Acceleration	Exceeding of acceleration values
	Offshore erection	Registration of components of limited acceleration	Checking all components for a limit of acceleration	Acceleration	Exceeding of acceleration values

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.3.11
Damage to object to be trans-ported and transport equipment Damage to fix and floating objects and environment	very high risk	Check all components of the object to be transported for max. acceleration values Calculate max. allowed weather and sea state conditions for max. allowed accele-ration	very good	4	medium risk	
Damage to object to be trans-ported and transport equipment Damage to fix and floating objects and environment	very high risk	Check all components of the object to be transported for max. acceleration values Calculate max. allowed weather and sea state conditions for max. allowed accele-ration	very good	4	medium risk	
Damage to object to be trans-ported and transport equipment Damage to fix and floating objects and environment	very high risk	Observe the weather criteria for transport Monitor the acceleration values by means of appropriate measuring and recording instruments during transport If necessary, modify course and speed during transport	very good	4	medium risk	
Damage to object to be trans-ported and transport equipment Damage to fix and floating objects and environment	very high risk	Observe the weather criteria for instal-lation Monitor the acceleration values by means of appropriate measuring and recording instruments during installation If necessary, modify course and speed during installation	very good	4	medium risk	

9.3 Engineering, transport of transformer station

9.3.12 Approval by MWS

9.3.12	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore transports	Approval by MWS	Execution of a transport-relevant approval	Approval	Error during approval due to insufficient knowledge of MWS Error during approval due to insufficient information by client
	Execution planning of offshore erection	Approval by MWS	Execution of an installation-relevant approval	Approval	Error during approval due to insufficient knowledge of MWS Error during approval due to insufficient information by client

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.3.12
Damage to or loss of objects to be trans-ported Damage to fix and floating objects and environment	high risk	Look for appropriate MWS companies Verify references as to sufficient experience during approval / general approval of the transport section in question Draw up a catalogue of the documents to be verified Verify certified documents, only Verify compliance with certified measures including on-site implementation In case of discrepancies, stop the approval and verify the information / measures	very good	3	low risk	
Damage to or loss of objects to be trans-ported Damage to fix and floating objects and environment	high risk	Look for appropriate MWS companies Verify references as to sufficient experience during approval / general approval of the installation stages in question Draw up a catalogue of the documents to be verified Verify certified documents, only Verify compliance with certified measures including on-site implementation In case of discrepancies, stop the approval and verify the information / measures	very good	3	low risk	

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9.3.13 Verification by certifier of the method statements

9.3.13	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore transports	Verification by certifier of the method statements	Verification of method statements	Method statements (method statements)	Wrong documents that do not reproduce the processes Missing or insufficient documents
	Execution planning of offshore erection	Verification by certifier of the method statements	Verification of method statements	Method statements (method statements)	Wrong documents that do not reproduce the processes Missing or insufficient documents

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.3.13
Faulty certification No homologation or refusal of homologation Homologation delayed Project delayed	high risk	Select appropriate and experienced certifier Early and direct contact to the certifier to clear sequences and procedures of certification Document management to reproduce and establish the process and corresponding documentation in its entirety Make certifier carry out certification audits to ensure and verify the procedures Check process sequences on-site during transport	very good	3	low risk	
Faulty certification No homologation or refusal of homologation Homologation delayed Project delayed	high risk	Select appropriate and experienced certifier Early and direct contact to the certifier to clear sequences and procedures of certification Document management to reproduce and establish the process and corresponding documentation in its entirety Make certifier carry out certification audits to ensure and verify the procedures Check process sequences on-site during installa-tion	very good	3	low risk	

9.3 Engineering, transport of transformer station

9.3.14 Delay due to bad weather / vessel repair

9.3.14	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore transports and offshore erection	Delay due to bad weather and repairs of special ships	Planning of weather and sea state conditions for the use of transport and installation capacities	Weather and sea state	Conditions of weather and sea state beyond weather criteria
	Execution planning of offshore transports and offshore erection	Delay due to bad weather and repairs of special ships	Outage due to repair of special ships	Special ships	Technical breakdown of the special ships

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.3.14
Long-term delays and/ or failure of trans-port and installation activities	high risk	Exactly plan the project start (winter or summer) on the basis of weather statistics and weather criteria to adhere to Define as high weather and sea state criteria as technically possible and reasonable and observe them in the design and the chain of transport and installation Plan the use of units on a daily basis and use the current weather condi-tions and development as well as possible criteria of use as a basis, too	adequate	6	medium risk	Observance of weather conditions Development of a detailed weather and meteo-ocean plan of the installation site to well comprehend the weather there Inclusion of delay costs in CAPEX Weather insurance to be effected	
Due to the limited availability of special ships, delivery of spare parts, repair capaci-ties: long-term delays, or stop of transport and installation activities Damage to and/or loss of objects to be trans-ported and installed Damage to fix and floating objects and environment	high risk	Select well-respected shipping companies Select ships classified in an IACS class Condition survey prior to chartering and/or use of a ship Ships belonging to shipyards and component manufacturers with a world-wide supporting network and reaction times of 24/7 Redundancy of ships	very good	3	low risk	Weather conditions to be met High technicization of the ships and daily rates Availability of spare parts and shipyard capacities and/or facilities Available for construc-tions on certain days, only Potential penalties due when electrical current is not delivered on-time	

9.4 Construction engineering of transformer station

9.4.1 Review of sea state and weather conditions

9.4.1	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore erection	Clearing up allowed sea state and weather conditions with MWS / certifier	Planning of different assembling stages	Weather conditions	Wrong verification of assembling
	Execution planning of offshore erection	Clearing up allowed sea state and weather conditions with MWS / certifier	Definition of weather, sea state, and flow criteria to provide for safe transport and installation on the basis of weather, sea state, and flow statistics for the respective area and period of assembling	Weather conditions	Wrong basis of statistical data for the area and period of assembling
	Execution planning of offshore erection	Clearing up allowed sea state and weather conditions with MWS / certifier	Structural implementation of the requirements for the installation objects and the sea-fastening on the basis of weather / sea state statistics	Weather conditions	Wrong construction of installation objects and sea-fastening

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.4.1
Wrong definition of maximum weather and sea state criteria Damage to topside and other prefabricated sections Assembling delayed	high risk	Exactly plan the individual assembling stages Close co-ordination with design engineers and the contractors for transport and installation Make certifier / MWS clear up and verify	very good	3	low risk	Professional indemnity Hull & machinery P&I Charterer's liability	
Wrong definition of maximum weather and sea state criteria Damage to topside and other prefabricated sections Assembling delayed	high risk	Select the relevant statistical data on the basis of the exact schedule for area and period of assembling Opt for weather providers experienced in the offshore area to deliver weather statistics Make certifier / MWS verify this	very good	3	low risk	Professional indemnity Hull & machinery P&I Charterer's liability	
Damage to topside and other installation sections Installation delayed	high risk	Define the structural requirements by exact planning of the installation stages Closely co-ordinate with design engineers and the shipyard Make certifier / MWS verify this	very good	3	low risk	Professional indemnity Hull & machinery P&I Charterer's liability	

9.4 Construction engineering of transformer station

9.4.2 Release of installation procedures by the person in charge of project certification

9.4.2	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore erection	Release of installation procedures by the person in charge of project certification	Verification and release of installation procedures (method statements)	Installation procedures (method statements)	Missing or incomplete documents Faulty installation procedures that do not reflect the actual steps and sequences Wrong assumptions for design and execution

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.4.2
Delay in verification / release of the installati-on procedures Damage / accidents during transport and installation Installation infeasible due to wrong assump-tions	high risk	Select experienced certifier Co-ordinate with certifiers the certifying procedure Furnish proof of all valid documents (document management) Kick-off meeting on the execution of the individual transport and installation stages and check against the intended methods Check when processes are running	very good	3	low risk	

9.4 Construction engineering of transformer station

9.4.3 Engineering of pre- & post-piling

9.4.3	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore erection	Planning complete: pre- / post-piling	Selection of piling method	Technology	The installation steps are appropriate for the piling technology (e.g. no pile driving template, wrong installation equipment, etc.)
	Execution planning of offshore erection	Planning complete: pre- / post-piling	Pre-piling	Pile driving template	Wrong pile driving template Does not correspond to the actually required distance between piles and pile sizes for the jacket

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.4.3
Piling and installation impossible	high risk	Exactly define the piling technology and the indivi-dual steps Make external surveyors verify this	very good	3	low risk	
The jacket cannot be installed Position to be rejected Ready-made and/or installed cables to be rejected Entire installation delayed	high risk	Use only one pile driving template Exactly mark the pile driving templates if several	very good	3	low risk	

9.4 Construction engineering of transformer station

9.4.4 Soil investigation

9.4.4	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Soil investigation	Soil investigation	Geotechnical and geophysical investigations of the building ground	Soil	Insufficient stability at the installation position Impossible to drive piles into the hard subsoil Insufficient levelling due to variations in the thickness of bearing beds (ruggedness); Objects on the positions of piles (ammunition)

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.4.4
Installation of the topside / baseframe at the planned position is impossible; position has to be turned down Impossible to drive the piles down to the planned depth Piles not designed for this soil Piles have become stuck in the ground and are blocked by an object Ammunition in the pile driving field, explosion followed by damage to / loss of pile, installation units, personnel Position perhaps to be rejected	very high risk	Geotechnical and geophysical investigations to rate the soil quality Ground scans to determine any stratification and to locate any objects in the installation area Logs per pile position as well as CPTs to determine the geophysical characteristics of stratification and use them to draw up a feasibility study for pile-driving Survey the bearing stratum and the ground levels and examine the resulting measures (excavation to adjust the level) Apply conservative approach (high safety) Verify the soil investigations and their consequences / results through independent expert opinions Design and carry out construction on the basis of such investigations (e.g. pile sizes, ADÜ?) Use appropriate equipment, such as vibro hammer, pile hammer Levelling devices Remove any ammunition and other objects in the installation area	adequate	8	high risk	Detailed geotechnical and geophysical investigation during development Detailed platform design to detect sensitive areas and design margins Design should be verified by a third party Design should be proven and realised by experienced design engineers	

9.4 Construction engineering of transformer station

9.4.5 Positioning, bubble curtain, mooring, DP, and jacking

9.4.5	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	l)	Positioning Bubble curtain Mooring DP and jacking	Use of bubble curtain system to reduce the propagation of hammering sound (relieved foundation systems / monopiles)	Bubble curtain systems	Failure and loss of the system
	k)	Positioning Bubble curtain Mooring DP and jacking	Use of bubble curtain system to reduce the propagation of hammering sound (relieved foundation systems / monopiles)	Tugboat Supply vessel	Failure of installation units: ▪ Technical failure ▪ Improper use ▪ Use beyond limitation of use
	l)	Positioning Bubble curtain Mooring DP and jacking	Use of bubble curtain system to reduce the propagation of hammering sound (relieved foundation systems / monopiles)	Weather conditions and sea state	Heavy wind, gusts Sea too rough Tide
	k)	Positioning Bubble curtain Mooring DP and jacking	Dynamic positioning of crane ship / tugboat	Crane vessel Tugboat AHT Supply vessel Jack-up vessel	Malfunction of DP system during installation: ▪ no DP trail ▪ load distribution on the ship ▪ non-observance of limitation of use ▪ malfunction of sensors / measuring error ▪ Technical failure
	k)	Positioning Bubble curtain Mooring DP and jacking	Dynamic positioning of crane ship / tugboat	Weather conditions and sea state	Heavy wind, gusts Sea too rough Tide

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.4.5
No sound-reducing measures possible Pile installation work delayed Entire project delayed	medium risk	Maintain and inspect the system prior to any use Redundant system Spare parts Skilled and trained personnel	adequate	4	medium risk	
Impossible to lower into water / install the system Pile installation work delayed Entire project delayed	medium risk	Select well-respected, experienced, and certified shipping companies (ISO, ISM, IMCA) Early draw up a condition survey of the units and equipment used to find adequate replacement where necessary Qualified and trained crew Contingency plan for lack of tugboats / supply vessels (ISM) Access to stand-by tugboats / supply vessels	adequate	4	medium risk	
Impossible to build up bubble curtain and, consequently, the latter is ineffective Pile installation work delayed Entire project delayed	medium risk	Define appropriate weather criteria Check the weather reports Carry out operations under defined weather condi-tions only	adequate	4	medium risk	
Maritime units drifting during installation Collision with fixed and floating objects / items Damage to objects / items Delay during installa-tion	medium risk	Carry out maintenance work as required by the manufacturer Check all units for their use in the field DP trail prior to starting any work Use qualified and trained personnel for operation and maintenance	very good	2	low risk	
Impossible to reach or keep position	high risk	Define appropriate weather criteria Check the weather reports Carry out operations under defined weather condi-tions and in the corresponding weather slot, only	very good	3	low risk	

9.5 Erection of transformer station

9.5.1 Planning of vessels, barges, etc.

9.5.1	Process steps	Short description of operation	Requirements for the operation	Marine spread	Requirements	Risks
	Execution planning of offshore transports	Planning and assessment of necessary ships, barges, ... (proof of class)	Identification / calculation of the ship, tugboat, barge capacities required Tugging equipment (marine spread) based on industrial standards (DNV, GL Noble Denton, London Offshore, etc.)	Crane ship		Crane ships Tugboat AHT Barges Supply vessels Jack up barges / vessels etc. Equipment
	Execution planning of offshore transports	Planning and assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified requirements Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews		Lifting capacities Positioning conditions (DP, 4 points mooring) Navigational restrictions	
	Execution planning of offshore transports	Planning and assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified requirements Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews	Tugboat	Machine output Operating radius Positioning conditions (DP, 4 points mooring) Navigation restrictions	
	Execution planning of offshore transports	Planning and assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified requirements Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews	AHT	Anchor handling capacity Static pull Positioning conditions (DP, 4 points mooring) Navigation restrictions	

Events	Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.5.1
Unsuitable tugboats AHT barges supply vessels jack up barges / vessels etc. equipment	Failure of units used and corresponding delay for project	medium risk	Select well-respected, experienced, and certi-fied shipping companies (ISO, ISM, IMCA) Early draw up a condition survey of the units and equipment used to find adequate replacement (where necessary)	adequate	4	medium risk	

9.5.1	Process steps	Short description of operation	Requirements for the operation	Marine spread	Requirements	Risks
	Execution planning of offshore transports	Planning and assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified requirements Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews	Barges	Dimensions Load bearing capacity Submergible	
	Execution planning of offshore transports	Planning and assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified requirements Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews	Supply vessel	Deck surface area Deck capacities Crane capacity Navigation restrictions	
	Execution planning of offshore transports	Planning and assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified requirements Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews	Jack-up barge Vessel	Operation - water depths, survival conditions Deck surface area Crane capacities Positioning conditions (DP, 4-point mooring) Accommodation Navigation restrictions	
	Execution planning of offshore transports	Planning and assessment of necessary ships, barges, ... (proof of class)	Market analysis on the basis of the identified requirements Availability of marine spread Inspection of the condition of planned ship units, barges, tugboats Check of the shipping companies Check of the crews	Cable layer	???	

Events	Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.5.1

9.5 Erection of transformer station

9.5.2 Setting down the base structure onto the seabed

9.5.2	Process steps	Short description of operation	Requirements for the operation	Require-ments in detail	Risks	Events
	Offshore erection	Setting down the base structure onto the seabed	Positioning of base frame / topside on the seabed (pre-piling)		Pile position	Wrong setting down Impossible to positi-on the base frame due to wrong piling
	Offshore erection	Setting down the base structure onto the seabed	Positioning of base frame / topside on the seabed (post-piling)	Tolerances	Final position	Final position not within required limits
	Offshore erection	Setting down the base structure onto the seabed	Horizontal and vertical alignment of the base frame		Alignment	Seabed not levelled out (even) within the required limits Base frame not aligned within the required limits (horizontal and quarter)
	Offshore erection	Setting down the base structure onto the seabed	Weather and sea state criteria		Weather and sea state conditions	Heavy wind, gusts Sea too rough Too strong currents in the different depths of water

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.5.2
Re-lifting/jacking of the base frame and new attempt to position it within limits: possible damage to base frame or piles Due to wrong piling installation position to be turned down Installation and entire project delayed	high risk	Take exact dimensions of pile positions for installation of the base frame Develop a method to set down and exactly position the base frame Select suitable measuring instruments and monitoring equipment Monitor setting down of the base frame and permanently check the actual against the desired position If required, lift the base frame again and restart positioning	adequate	6	medium risk	
Re-lifting/jacking of the base frame and new attempt to position it within limits: possible damage to base frame or piles Installation and entire project delayed	high risk	Develop a method to set down and exactly position the base frame Select suitable measuring instruments and monitoring equipment Monitor setting down of the base frame and permanently check the actual against the desired position If required, lift the base frame again and restart positioning	adequate	6	medium risk	
The base frame is out of limits Re-lifting/-jacking of the base frame and new attempt to position it within limits: possible damage to base frame or piles Seabed to be levelled out Installation and entire project delayed	high risk	Have soil surveys drawn up Where required and possible take improving measures (excavation, levelling layers) and/or use levelling technology Take reading of alignment after setting down of the base frame on the seabed Level by application of corresponding pile method	very good	3	low risk	
Exact positioning impossible	high risk	Check wether the weather reports meet the weather criteria Plan positioning exactly Monitor present weather conditions	adequate	6	medium risk	

9.5 Erection of transformer station

9.5.3 Piling, fixing

9.5.3	Process steps	Short description of operation	Requirements for the operation	Require-ments in detail	Risks	Events
	Offshore erection	Piling to fix the base structure onto the seabed	Driving-in of piles	Pre-piling Post-piling	Piles	Piles' bearing capacity not as required
	Offshore erection	Piling to fix the base structure onto the seabed	Driving-in of piles	Vibro hammer Hydraulic hammer	Equipment	Failure due to technical fault of vibro/ hydraulic hammer
	Offshore erection	Piling to fix the base structure onto the seabed	Driving-in of piles		Sea ground	Unexpected seabed conditions, rocks and other objects
	Offshore erection	Piling to fix the base structure onto the seabed	Driving-in of piles		Sound / noise	The sound under water exceeds the BSH limits
	Offshore erection	Piling to fix the base structure onto the seabed	Weather and sea state criteria		Weather and sea state conditions	Heavy wind, gusts Sea too rough Too strong currents in the different depths of water

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.5.3
Impossible to drive in the pile at all or down to the planned depth Pile to be rejected as not useful anymore Loss of pile as stuck in the seabed; to be cut Possibly, position to be rejected	high risk	Soil investigations / expert opinions on geophysical characteristics Make expert in geophysics verify the results Driving study to be drawn up Define the driving force and use this to define the vibro/hydraulic hammer Design the piles corresponding to the results of the soil survey and driving study Use the piles required for the corresponding pile position and the corresponding vibro/hydraulic hammer Carry out and supervise the piling work by person-nel experienced in this field	very good	3	low risk	
Installation and driving work delayed Damage to piles or the pile driving template	high risk	Redundancy of hammers Engineer(s) and spare parts on site	very good	3	low risk	
Impossible to reach the required depth of penetration Driving impossible Pile position to be rejected Project delayed	high risk	Soil investigations / soil survey (borehole logs, core penetration tests, soil scans)	adequate	6	medium risk	
Damage to marine animals	high risk	Take sound-reducing measures (box dam, bubble curtain, etc.) Frighten marine mammals away of the installation area Take readings proving compliance with allowed sound level and that marine mammals have been frightened away (e.g. POD)	adequate	6	medium risk	
Piling of base frame impossible Project delayed	high risk	Check wether the weather reports meet the weather criteria Exactly plan piling Monitor present weather conditions	adequate	6	medium risk	

9.5 Erection of transformer station

9.5.4 Grouting the base structure piles

9.5.4	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	f)	Grouting of the base structure piles	Selection of grouting material	Grouting material	Wrong grouting material selected; physical properties do not suit the planned use
	l)	Grouting of the base structure piles	Use and manipulation of grouting material	Grouting material	Too short hardening times before exerting any stress onto the grouted structure Non-observance of operating temperatures Wrong composition of grout components
	l)	Grouting of the base structure piles	Use of grouting equipment	Grouting equipment	Fault of grouting equipment Blocking and choking of grout pipes and hoses
	l)	Grouting of the base structure piles	Check and release of grouted structure	Grouted structure	Grouted structure released too early and without any check
	l)	Grouting of the base structure piles	Weather and sea state criteria	Weather conditions and sea state	Heavy wind, gusts Sea too rough Too strong currents in the different depths of water Temperatures too low

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.5.4
Grouted structure does not prove sufficient strength and, thus, its durability is insufficient Damage to grouted structure and total strength of structures Grouting and installation delayed	very high risk	Select experienced and certified grouting companies Select and use certified grouting material according to the specifications Monitor grouting and examine grout samples	very good	4	medium risk	
Grouted structure does not prove sufficient strength and, thus, its durability is insufficient Damage to grouted structure and total strength of structures Grouting and installation delayed	high risk	Select experienced and certified grouting companies Select and use certified grouting material according to the specifications Monitor manipulation of the grout under the required ambient conditions and examine ground samples	very good	3	low risk	
Grouted structure does not prove sufficient strength and, thus, its durability is insufficient Damage to grouted structure and total strength of structures Grouting and installation delayed	high risk	Select experienced and certified grouting companies Select and use reliable grouting equipment Redundancy Make engineer(s) of the grouting company operate the equipment Engineer(s) and spare parts on site Toolbox meeting before operation Monitor the grouting process Immediately clean equipment / pipes and hoses prior to longer downtimes	adequate	6	medium risk	
Grouted structure does not prove sufficient strength and, thus, its durability is insufficient Damage to grouted structure and total strength of structures Grouting and installation delayed	medium risk	Select experienced and certified grouting companies Select and use certified grouting material according to the specifications Monitor manipulation of the grout under the required ambient conditions and examine ground samples	very good	2	low risk	
Grouting of base frame impossible Project delayed	high risk	Check wether the weather reports meet the weather criteria Exactly plan grouting Monitor present weather conditions	adequate	6	medium risk	

9.5 Erection of transformer station

9.5.5 Floating into position and alignment of topside

9.5.5	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore transports	Floating into position and alignment of topside (separate and combined design)	Design of anchor grid	Base frame under water level Base frame and topside combined	Anchor grid	Anchor does not hold, shifting Too low holding load of anchors
	Offshore transports	Floating into position and alignment of topside (separate and combined design)	Connection of anchor grid to mooring/positio-ning equipment	Base frame under water level Base frame and topside combined	Anchor grid Mooring/ positioning system	Windlasses fail Broken mooring/ towing wire Tugboats fail

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.5.5
Loss of control of topside Contact / collision with other floating or fixed structures and/or units leads to property damage or damage to third objects Positioning / instal-lation and the entire project delayed	high risk	Exactly plan the installati-on of the anchor grid Scan the seabed to get current data regarding the position of already existing underwater objects (e.g. sea cable). Observe distances from existing sea cables required by industrial standards (e.g. GL Nobel Denton) and install floats / marker beacons where anchor or the mooring gear crosses sea cables Exactly define the positions and installation of the anchors on the positions Make independent expert verify this Pre-tension and check corresponding holding load of anchor handling tug Stand-by tugboats, which can rapidly take control of the topside Weigh the anchor and drop it again	very good	3	low risk	Potential damage to already existing sea cables or other under-water structures	
Loss of control of topside Contact / collision with other floating or fixed structures and/or units leads to property damage or damage to third objects Positioning / instal-lation and the entire project delayed	high risk	Exactly plan, calculate, and design the mooring and positioning system (windlasses, wire, tugboats, etc.) Let only experienced personnel operate the windlasses and/or tugboats So-called towmaster shall supervise floating in and positioning Toolbox meeting before taking action Test prior to using Redundancy (where possible) Engineers and spare parts on site / repair Stand-by tugboat	very good	3	low risk		

9.5.5	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore transports	Floating into position and alignment of topside (separate and combined design)	Floating in and positioning with mooring/ positioning system	Base frame under water level Base frame and topside combined	Mooring/ positioning system	Windlasses fail Broken mooring/ towing wire Tugboats fail
	Offshore transports	Floating into position and alignment of topside (separate and combined design)		Base frame under water level Base frame and topside combined	Electronic positioning/ measuring system	Failure of positioning/measuring system (computer, GPS, etc.)
	Offshore transports	Floating into position and alignment of topside (separate and combined design)		Structures of the base frame are above water level and designed as floating-in aids	Base frame	Contact and collision with the base frame

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.5.5
Loss of control of topside Contact / collision with other floating or fixed structures and/or units leads to property damage to the topside or damage to fixed and floating objects Positioning / installati-on delayed	high risk	Exactly plan, calculate, and design the mooring and positioning system (windlasses, wire, tugboats, etc.) Let only experienced personnel operate the windlasses and/or tugboats So-called towmaster shall supervise floating in and positioning Toolbox meeting before taking action Test prior to using Redundancy (where possible) Engineers and spare parts on site / repair Stand-by tugboat	very good	3	low risk		
No exact positioning of the topside above base frame Contact / collision with other floating or fixed structures and/or units leads to property damage or damage to third objects Towage and entire project delayed	high risk	Use different measuring systems Redundancy of systems Engineers on site who know the systems	very good	3	low risk		
Loss of control of base frame Contact / collision with other floating or fixed structures and/or units leads to property damage or damage to third objects Positioning / instal-lation and the entire project delayed	high risk	Exactly plan how to carry out floating into the base frame Let only experienced personnel operate the windlasses and/or tugboats So-called towmaster shall supervise floating in and positioning Toolbox meeting before taking action	very good	3	low risk		

9.5.5	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore transports	Floating into position and alignment of topside (separate and combined design)	Observance of weather and sea state criteria		Weather and sea state conditions	Heavy wind, gusts Sea too rough Too strong currents in the different depths of water

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	Comments	9.5.5
Impossible to lay the anchor grid and connect the mooring ropes to the anchor grid; positioning / installation delayed Impossible to floating in on the position; positioning / installati-on delayed	very high risk	Check wether the weather reports meet the weather criteria Exactly plan loading out and piling Monitor present weather conditions	adequate	8	high risk		

9.5 Erection of transformer station

9.5.6 Jacking up the topside

9.5.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore erection	Jacking procedure, topside (if any)	Check of trimming/ heeling level for jacking		Trimming/ heeling level	Too much trimming/ heeling of topside
	Offshore erection	Jacking procedure, topside (if any)	Jacking down of legs		Jack-up system	Fault of jack-up system
	Offshore erection	Jacking procedure, topside (if any)	Guiding of the legs into the structure		Topside	Collision of the topside legs with the base frame / piles
	Offshore erection	Jacking procedure, topside (if any)		Cameras ROV Shock absorber	Underwater guiding / positioning aids	Failure of and/or damage to the guiding / positioning aids
	Offshore erection	Jacking procedure, topside (if any)			Electronic positioning system	Failure of positioning system (computer, GPS, etc.)

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.5.6
Jacking impossible Jacking and installation process delayed	high risk	Exactly plan, calculate, and execute the process Design accordingly to minimise ballasting Take required ballast into account when designing the jacking system Ballast in the shipyard for towing and jacking of the topside Use pump systems for ballasting (if required)	very good	3	low risk	
Jacking impossible Jack-up and installation delayed	very high risk	Use of certified systems and experienced compa-nies, only Exactly plan, calculate, and design the jacking system (e.g. sufficient safety margins, suitable for offshore use) Make qualified personnel of the supplier of the jacking system operate the system Redundancy of jacking system components as far as possible	adequate	8	high risk	
Damage to the legs of the topside and to the base frame / piles Installation and entire project delayed	very high risk	Exactly plan how to insert the legs Observe distances, tidal range, etc. Prior to operation toolbox meeting of anyone invol-ved in the process with stop criteria and responsi-bilities Make only qualified personnel of the supplier of the jacking system operate the system Use visual underwater monitoring systems for position and distance control (e.g. ROV, diver, camera, distance marks on the legs and the base frame / pile) Surface markings to determine the distance of legs and base frame / piles	very good	4	medium risk	
Impossible to insert the legs into the base frame / piles as a consequence of the failure of and/or damage to the guiding/ positioning aids Jacking and installation process delayed	high risk	Exactly plan how to insert the legs and use appro-priate guiding and positioning aids (suitable for underwater use, shock-resistant, etc.) Redundancy of systems (where possible) Make only qualified personnel operate the system Prior to operation toolbox meeting of anyone invol-ved in the process with stop criteria and responsi-bilities	very good	3	low risk	
Impossible to exactly position the topside above the base frame and, therefore, impossi-ble to insert the legs Positioning / installati-on delayed	high risk	Use different measuring systems Redundancy of systems Engineers on site who know the systems	very good	3	low risk	

9.5.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore erection	Jacking procedure, topside (if any)	Jacking up the topside		Jack-up system	Fault of jack-up system
	Offshore erection	Jacking procedure, topside (if any)	Observance of weather and sea state criteria		Weather and sea state conditions	Heavy wind, gusts Sea too rough Too strong currents in the different depths of water

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.5.6
Jacking impossible Damage to the topside and/or the legs occurs if the topside has not been jacked up out of the tidal limit or wave peak (slamming) Jack-up and installation delayed	very high risk	Use of certified systems and experienced compa-nies, only Exactly plan, calculate, and design the jacking system (e.g. sufficient safety margins, suitable for offshore use) Make only qualified personnel of the supplier of the jacking system operate the system Redundancy of jacking system components as far as possible Exactly plan and execute the process Prior to operation toolbox meeting of anyone invol-ved in the process with stop criteria and responsi-bilities	adequate	8	high risk	
Jacking impossible Damage to topside by slamming Jack-up and installation delayed	very high risk	Check wether the weather reports meet the weather criteria Exactly plan jacking Monitor present weather conditions	adequate	8	high risk	

9.5 Erection of transformer station

9.5.7 Lifting the topside

9.5.7	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore erection	Lifting the topside (if any)	Fastening the spreader	Slings Shackles etc.	Load-in/out equipment	Selection of improper load-out equipment because of wrong load-out method Selection of improper load-out equipment because of wrong weights and/or dimensions Load-out equipment defective No appropriate fastening points
	Offshore erection	Lifting the topside (if any)	Releasing of sea-fastening		Sea-fastening	Lifting of the topside to completely release the sea-fastening Sea-fastening under load (AdÜ?), thus sea-fastening becomes released before it will be completely disconnected
	Offshore erection	Lifting the topside (if any)	Lifting procedure		Crane ship	Damage to crane ship (e.g. damage to the windscreen of the crane, twisting of the crane rope, damage to the crane rope as it runs over sharp edges, damage to the boom due to contact with the topside, etc.)
	Offshore erection	Lifting the topside (if any)	Lifting procedure (lifting and depositing)		Lifting	Swinging, twisting, and slamming of topside (slamming = Aufschlagen des Schiffsbodens auf die Wasseroberfläche bei Seegang AdÜ?) Loads unevenly distributed (centre of gravity far beyond vertical axis of the topside)
	Offshore erection	Lifting the topside (if any)	Observance of weather and sea state criteria		Weather and sea state conditions	Heavy wind, gusts Sea too rough Too strong currents in the different depths of water

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.5.7
Impossible to load out Touch up the design Lifting and entire installation of topside delayed	medium risk	Exactly plan lifting Calculate and design the topside so as to suit lifting Provide the topside with suitable, certified fastening points Select suitable spreader with certifications Select appropriate suppliers / check of/by (AdÜ?) suppliers Make certifier / MWS verify this Visually inspect the spreader prior to any use	very good	2	low risk	
Damage to and/or loss of topside, crane ship, barge, spreader	medium risk	Exactly plan disconnection of sea-fastening Draw up corresponding plan (exact releasing sequence for sea-fastening, use of tools, safety measures to be taken, etc.) Toolbox meeting before taking action Use of experienced personnel Use of appropriate tools Protect the topside against damage and/or loss (e.g. fasten the crane before disconnection of the sea-fastening) Monitor disconnection	very good	2	low risk	
Damage to and/or loss of topside Lifting and, conse-quently, installation of topside delayed due to failure of the crane ship	high risk	Select a suitable crane ship for lifting Check the class and other certificates (among other things: crane certificates of class and test reports) Check whether maintenance and test intervals have been observed Carry out visual inspection and function test prior to any use	adequate	6	medium risk	
Falling of the spreader from the hooks Damage to the topside, the crane ship, the barge, and/or other structures due to contact / collision with the topside,	very high risk	Use experienced and qualified crane drivers Toolbox meeting before taking action to define (AdÜ) stop criteria Take safety measures to prevent swinging, rotating of the topside (e.g. tug ropes and tug winches) Take safety measures on the hook to prevent falling of the spreader from the hooks Make the supervisor monitor the lifting procedure	adequate	8	high risk	
Lifting impossible Lifting and, thus, entire installation delayed	high risk	Check wether the weather reports meet the weather criteria Exactly plan lifting Monitor present weather conditions	adequate	6	medium risk	

9.5 Erection of transformer station

9.5.8 Grouting the topside

9.5.8	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore erection	Grouting the topside	Selection of grouting material	Grouting material	Wrong selection of grouting material Physical properties do not suit the planned use
	Offshore erection	Grouting the topside	Use and manipulation of grouting material	Grouting material	Too short hardening times before exerting any stress onto the grouted structure Non-observance of operating temperatures
	Offshore erection	Grouting the topside	Use of grouting equipment	Grouting equipment	Fault of grouting equipment Blocking and choking of grout pipes and hoses
	Offshore erection	Grouting the topside	Examine and release grouted structure	Grouted structure	Grouted structure released too early and without any check
	Offshore erection	Grouting the topside	Weather and sea state criteria	Weather and sea state conditions	Heavy wind, gusts Sea too rough Too strong currents in the different depths of water Temperatures too low

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.5.8
Grouted structure does not prove sufficient strength and, thus, its durability is insufficient Damage to grouted structure and total strength of structures Grouting and installation delayed	very high risk	Select experienced and certified grouting companies Select and use certified grouting material according to the specifications Monitor grouting and examine grout samples	very good	4	medium risk	
Grouted structure does not prove sufficient strength and, thus, its durability is insufficient Damage to grouted structure and total strength of structures Grouting and installation delayed	high risk	Select experienced and certified grouting companies Select and use certified grouting material according to the specifications Monitor manipulation of the grout under the required ambient conditions and examine ground samples	very good	3	low risk	
Damage to grouted structures or grouting equipment and total strength of structures Grouting and installation delayed	high risk	Select experienced and certified grouting companies Select and use reliable grouting equipment Redundancy Make engineer(s) of the grouting company operate the equipment Engineer(s) and spare parts on site Toolbox meeting before taking action Monitoring of grouting process Immediately clean equipment / pipes and hoses prior to longer downtimes	adequate	6	medium risk	
Grouted structure does not prove sufficient strength and, thus, its durability is insufficient Damage to grouted structure and total strength of structures	medium risk	Select experienced and certified grouting companies Select and use certified grouting material according to the specifications Monitor manipulation of the grout under the required ambient conditions and examine ground samples	adequate	2	low risk	
Impossible to carry out grouting Grouting and installation delayed	high risk	Check wether the weather reports meet the weather criteria Exactly plan grouting Monitor present weather conditions	adequate	6	medium risk	

9.6 Foundations of offshore wind turbines

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	b)	Soil investigation	Geological, geotechnical, and geophysical investigations of the building ground		Soil	Insufficient stability at the installation position Impossible to drive piles into the hard subsoil Insufficient levelling due to variations in the thickness of bearing beds (ruggedness) Objects on the positions of piles (ammunition) Unfavourable soil conditions (e.g. soft sediments) Insufficient soil investigation (e.g. inappropriate geophysical methods)
	a)	Soil investigation	Preliminary soil investigation		Representative locations	Locations do not represent (10 %) the soil predominant for installation Soil changes are not detected e.g. couloirs, Elbe Urstromtal
	b)	Soil investigation	Analysis		Unfavourable perhaps only local strata not detected Considerable covered risks resulting therefrom, which could occur even later during the operation of the wind farm	Poor / insufficient investigation and/or investigation method Poor analysis/interpretation of data

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Impossible to install the footing structure at the planned position so that the position has to be turned down Impossible to drive the piles down to the planned depth Piles not designed for this soil Piles have become stuck in the ground and are blocked by an object Ammunition in the pile driving field, explosion followed by damage to / loss of pile, installation units, personnel Foundations have to be adjusted to unfavou-rable soil conditions (e.g. lengthening); this causes delay, consi-derable increase in costs Insufficient soil investigation: risks for stability and usability can occur (even later when the wind farm will be in operation)	very high risk	Geotechnical and geophysical investigations to rate the soil quality Ground scans to determine any stratification and to locate any objects in the installation area Logs per pile position as well as CPTs to determine the geophysical characteristics of stratification and use them to draw up a feasibility study for pile-driving Survey the bearing stratum and the ground levels and examine the resulting measures (excavation to adjust the level) Apply conservative approach (high safety) Verify the soil investigations and their consequences / results through independent expert opinions Design and carry out construction on the basis of such investigations (e.g. larger pile size) Use appropriate equipment, such as vibro hammer, pile hammer, levelling devices Remove any ammunition and other objects in the installation area	adequate	8	high risk	
Footing structure impossible, new plans Layout of the farm to be revised	medium risk	Extensive desktop study to select locations Analyse the structure of strata with geophysical methods Early carry out the main soil investigation	adequate	4	medium risk	
Footing structure impossible, new plans Location to be rejected Project delay, which could entail high conse-quential costs Risks of liability	high risk	Soil investigations of highest possible quality (state of the art) Good geophysics give a comprehensive overview over the entire area and help to identify potential fields of risk Work done by qualified personnel	very good	3	low risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	b)	Soil investigation	Execution		Geotechnical conditions worse than expected Foundation / pile design to be revised	Stability of the structure not ensured Settlement / inclination Scouring
	a)	Soil investigation	Preliminary soil investigation (investigation of the soil to prove its suitability)		Archaeological finds Contamination Ammunition Wrecks Monolithes Containers	Poor or no investigation at all New contaminations
	b)	Load-bearing stratum	Determination of load-bearing bed		Stability Excavation depth	Poor analysis of the structure of strata Poor interpretation of the results of investigation Unexpected run of the strata in the area of footing
	b)	Structure of strata	Feasibility of installation		Feasibility of installation	Existence of spot objects (e.g. erratic blocks) Clay band and/or stratification too dense These are difficult to find (geological and geotechnical investigation could be misleading)
	e)	Basic installation concept	Draw up an installation concept	Co-ordination of the procedures and installation sequences	Construction time Weather risks	Time shifting e.g. damage to ships, technical delays, etc. Weather conditions

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Footing structure impossible / unsuitable, new plans required Footing structure to be revised (stability, inclination)	high risk	Detailed geotechnical, geological, and geophysical investigation during development Design should be verified by a third party Design should be proven and realised by experienced design engineers	very good	3	low risk	
Construction delayed due to additional measures of investiga-tion and site clearing Installations impossible	medium risk	Geophysical investigations of the projected area (seismics, magnetics) Early desktop study Soil investigation prior to any installation	adequate	4	medium risk	
Insufficient stability Inclination of the wind turbines Supplementary excava-tion required	medium risk	Detailed soil investigation (preliminary soil investi-gation and main soil investigation) Quality management for analysis of investigation results (experienced employees) Analyse the structure of strata with geophysical and geotechnical methods Desktop study	very good	2	low risk	
Impossible to install the suction bucket Suction bucket becomes stuck during installation Damage to suction bucket (e.g. buckling); even loss of footing structure possible	medium risk	Sufficient geological and geotechnical investigations Make appropriate geophysical investigations to exclude such objects (erratic blocks) for the whole area Sturdy design of suction bucket (buckling, flushing devices)	very good	2	low risk	
Non-linear project delay due to the concept (effect of weather conditions) Too short / long charter periods Interaction of sub-projects (mains connection vs. installa-tion of wind turbines)	very high risk	Consider the offshore weather conditions in detail for planning of the installation concept (locally / globally) Analyse different scenarios of the interaction of sub-projects Check the project plans for their sensivity to changes in the project start / to project or sub-project delays	very good	4	medium risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	e)	Basic installation concept	Sequence / principle of the installations of wind farm components		Limitations of use of equipment Duration of offshore activities	Project delayed
	e)	Planning / assessment of necessary ships, barges, etc. (proof of class)	Identification / calculation of the required capacities of ships, tugboats, barges, of the tugging equipment (marine spread) based on industrial standards (DNV, GL Noble Denton, London Offshore, etc.)	Crane ship: lifting capacities, positioning conditions (DP, 4-point mooring), navigational restrictions Tugboat: machine output, operating radius, positioning conditions (DP, 4-points mooring), navigational restrictions AHT: Anchor handling Capacity: static pull, positioning conditions (DP, 4-points mooring), navigational restrictions Barges: dimensions, load-bearing capacity, submersible	Crane ships Tugboats AHT Barges Supply vessels Jack up barges / vessels Equipment etc.	Unsuitable (project requirements or technical condition): Crane ships Tugboats AHT Barges Supply vessels Jack up barges / vessels Equipment etc.

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Due to a delay the execution times considerably change as the weather becomes worse e.g. cable installation shifted from summer to autumn	high risk	Use of sturdy equipment Check the weather slot in detail Analyse different scenarios Check the project plans for their sensivity to changes in the project start / to project or sub-project delays	very good	3	low risk	
Failure of units used and corresponding delay for project Damage to cargo and ships Damage in the field of HSE	medium risk	Select well-respected, experienced, and certified shipping companies (ISO, ISM, IMCA) Early draw up a condition survey of the units and equipment used to find adequate replacement (where necessary) Adhere to classification restrictions for operation of vessels	adequate	4	medium risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	e)	Clearing up allowed sea state and weather conditions with MWS / certifier	Planning of the individual steps of transport and installation incl. definition of weather, sea state, and flow criteria on the basis of weather, sea state, and flow statistics for the respective area and period of assembling	Definition of weather, sea state, and flow criteria to provide for safe transport and installation on the basis of weather, sea state, and flow statistics for the respective area of transportation and installation	Weather conditions; e.g. wind, sea state, flow	Wrong basis of statistical data for the area and period of assembling Application of statistical data not allowed Wrong verification of transport and installation stages
	e)	Clearing up allowed sea state and weather conditions with MWS / certifier	Consideration of theoretical values for statics, dynamics, acceleration and fatigue of the foundations		Weather conditions	Wrong dimensioning or consideration of criteria or consideration in the T&I planning (AdÜ Abk. EN? s.u.) but not for implementation Poor communication between the design engineers of the foundation and the T&I planners
	e)	Clearing up allowed sea state and weather conditions with MWS / certifier	Structural design and implementation of requirements for objects to be transported and sea-fastening on the basis of defined sea state and weather conditions		Weather conditions	Design faults Faults when installing the transport and installation equipment onto the object to be transported
	e)	Registration of components of limited tipping angle	Checking all components for a limit of heeling/tipping angle		Tipping angle	Insufficient information about permitted angle of heeling/tipping

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Wrong definition of maximum weather and sea state criteria Damage to foundation and other prefabricated sections Assembling and/or entire project delayed Damage to fix and floating objects and environment	very high risk	Exactly plan the individual assembling stages Close co-ordination with design engineers Select the relevant statistical data on the basis of the exact schedule for area and period of assem-bling Use other methods of weather analysis, e.g. direct simulation Consider extreme years (best case / worst case consideration) Define realistic weather criteria for processes and the project area and the time when towing will take place Check wether the weather reports meet the weather criteria Opt for weather providers experienced in the offshore area to deliver weather statistics Make certifier / MWS verify this	very good	4	medium risk	
Wrong definition of maximum weather and sea state criteria Damage to foundation and other prefabricated sections (e.g. initial damages) Stability problems (e.g. as-constructed condi-tions) Assembling delayed	high risk	Closely interlock the design and the concept of transport / logistics Select design engineers experienced in offshore projects Make certifier / MWS verify this	very good	3	low risk	
Wrong definition of maximum weather and sea state criteria Damage to foundation and other objects to be transported Damage to fix and floating objects and environment Transport and/or lifting operations and entire project delayed	high risk	Define the design requirements by exact planning of the transport sections and installation stages Close co-ordinate with design engineers and the manufacturer Make certifier / MWS verify this	very good	3	low risk	
Damage to and/or loss of object to be transported / transport equipment Damage to fix and floating objects and environment	high risk	Check all components of the object to be trans-ported for max. angle of heeling/tipping Calculate max. allowed weather/sea state condi-tions for max. allowed angle of heeling/tipping	very good	3	low risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	f)	Registration of components of limited tipping angle	Checking all components for a limit of heeling/tipping angle		Tipping angle	Insufficient information about permitted angle of heeling/tipping
	k)	Registration of components of limited tipping angle	Checking all components for a limit of heeling/tipping angle		Tipping angle	Exceeding of angle of heeling/tipping
	l)	Registration of components of limited tipping angle	Checking all components for a limit of heeling/tipping angle		Tipping angle	Exceeding of angle of heeling/tipping
	e)	Registration of components of limited tipping angle			Susceptibility of components Heeling to waves and wind (enlarged surface exposed to the wind) Vibrations	Prevailing weather conditions Poor weather forecast Design of dynamic loads
	e)	Registration of components of limited acceleration	Checking of all components for limited acceleration		Acceleration	Insufficient information about permitted acceleration values
	f)	Registration of components of limited acceleration	Checking all components for a limit of acceleration		Acceleration	Insufficient information about permitted acceleration values

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Damage to and/or loss of object to be transported / transport equipment Damage to fix and floating objects and environment	high risk	Check all components of the object to be transported for max. angle of heeling/tipping Calculate max. allowed weather/sea state conditions for max. allowed angle of heeling/tipping	very good	3	low risk	
Damage to and/or loss of object to be transported / transport equipment Damage to fix and floating objects and environment	high risk	Observe the weather criteria for transport and installation Monitor the angle of heeling/tipping by means of appropriate measuring and recording instruments during transport and installation	very good	3	low risk	
Damage to and/or loss of object to be transported / transport equipment Damage to fix and floating objects and environment	high risk	Observe the weather criteria for transport and installation Monitor the angle of heeling/tipping by means of appropriate measuring and recording instruments during transport and installation	very good	3	low risk	
Damage to the foundation structure Transport and installation procedures delayed	high risk	Sturdy design of the foundation structure (dynamic loads, as-constructed conditions) Define and observe the corresponding weather criteria required for transport and installation Monitor the heeling/tipping angle	very good	3	low risk	
Damage to object to be transported / transport equipment Damage to fix and floating objects and environment	high risk	Check all components of the object to be transported for max. acceleration values Calculate max. allowed weather and sea state conditions for max. allowed acceleration	very good	3	low risk	
Damage to object to be transported / transport equipment Damage to fix and floating objects and environment	high risk	Check all components of the object to be transported for max. acceleration values Calculate max. allowed weather and sea state conditions for max. allowed acceleration	adequate	6	medium risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	k)	Registration of components of limited acceleration	Checking of all components for limited acceleration		Acceleration	Exceeding of acceleration values
	l)	Registration of components of limited acceleration	Checking of all components for limited acceleration		Acceleration	Exceeding of acceleration values
	e)	Ports and routes	Identification of appropriate routes for the transport of foundations (incl. port conditions)	Navigation restrictions due to length, width, draught, and overhead clearances of the transport vehicle and/ or the cargo in locks, canals, narrows, under bridges, etc. International and national regulations for shipping	Route (ports of refuge and protection areas)	Inappropriate route, ports of refuge, protected areas due to limited navigational transport possibilities (draughts, widths of canals, narrows, lengths of locks, overhead clearances under bridges) Insufficient knowledge of the conditions / transport route Poor deck layout Poor knowledge of the port and the conditions prevailing there
	e)	Clearing up whether MWS will be available during offshore transport	Verification of MWS availability during transport		MWS	No MWS available No MWS available who is familiar with this transport section
	f)	Clearing up whether MWS will be available during offshore installation	Verification of MWS availability during installation		MWS	No MWS available No MWS available who is familiar with this transport section

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Damage to object to be transported / transport equipment Damage to fix and floating objects and environment	high risk	Observe the weather criteria for transport Monitor the acceleration values by means of appro-priate measuring/recording instruments during transport If necessary, modify course and speed during transport	very good	3	low risk	
Damage to object to be transported / transport equipment Damage to fix and floating objects and environment	high risk	Observe the weather criteria for installation Monitor the acceleration values by means of appro-priate measuring/recording instruments during installation If necessary, modify course and speed during installation	adequate	6	medium risk	
Transport impossible or longer transport route (distance, time) Transport and entire project delayed Damage to transport vehicle and/or the foundations, e.g. by taking the ground, collision with corresponding structures Loading impossible	high risk	Exactly plan the location of manufacture / base port Exactly plan the routes on the basis of: a) the given dimensions of the units to be trans-ported incl. cargo b) the applicable national and international regulati-ons and laws Plan in detail the route incl. ports, protection areas, ports of refuge Use canals Take the dimensions of the deck of the transport unit	very good	3	low risk	
No general approval / approval of the individu-al transport section Execution of the indivi-dual transport sections delayed Loss of weather slot for this transport section	medium risk	Contact insurance companies to ask for recommen-ded MWS companies Check 24/7-availability of MWS prior to entering into an agreement Verify references as to sufficient experience during approval / general approval of the transport section in question	very good	2	low risk	
No general approval / approval of the individu-al transport section Execution of the indivi-dual transport sections delayed Loss of weather slot for this installation stage	medium risk	Contact insurance companies to ask for recommen-ded MWS companies Check 24/7-availability of MWS prior to entering into an agreement Verify references as to sufficient experience during approval / general approval of the installation stages in question	very good	2	low risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	e)	Project engineering	Planning of transport concept		Deadlines missed	Poor / optimistic scheduling Poor / optimistic reserve times Weather conditions Unknown framework conditions (e.g. permits, conditions, failures, etc.)
	f)	Project engineering	Planning of installation concept		Deadlines missed	Poor / optimistic scheduling Poor / optimistic reserve times Weather conditions Unknown framework conditions (e.g. permits, conditions, failures, etc.)
	e)	Drawing up emergency plans / designation of responsible persons	Execution of HAZID / HAZOP		HAZID / HAZOP	No HAZID / HAZOP take place Process- and/or design-relevant dangers not recognised
	f)	Drawing up emergency plans / designation of responsible persons	Execution of HAZID / HAZOP		HAZID / HAZOP	No HAZID / HAZOP take place Process- and/or design-relevant dangers not recognised
	e)	Drawing up emergency plans / designation of responsible persons	Execution of risk assessment		Risk assessment	No or poor risk assessment take place

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Transport processes / commissioning delayed Vehicles missing	high risk	Solid project engineering Extensive analyses of the weather slots Concept of reserve times	adequate	6	medium risk	
Transport processes / commissioning delayed Vehicles missing	high risk	Solid project engineering Extensive analyses of the weather slots Concept of reserve times	adequate	6	medium risk	
Cargo and transport equipment, process execution, and the personnel involved at risk Damage to the cargo of equipment used (AdÜ: oder "und der einge-setzten Ausrüstung"? Transportation impos-sible	high risk	Execution of HAZID / HAZOP Analyse the risks and if required change the process and/or the design	very good	3	low risk	
Cargo and transport equipment, process execution, and the personnel involved at risk Damage to the cargo of equipment used (AdÜ: oder "und der einge-setzten Ausrüstung"? Installation impossible	high risk	Execution of HAZID / HAZOP Analyse the risks and if required change the process and/or the design	very good	3	low risk	
Risks are not detected and/or not analysed or wrongly assessed No conclusions to avoid risks / hazards Consequence: damage and accidents	high risk	Establish risk assessment for all transport proce-dures Identify correction and/or protection measures Implement correction and/or protection measures into the design, method statements, process sequences, QHSE procedures, training programmes, instructions for PPE, emergency concepts, etc. Complement or draw up a register of risks	very good	3	low risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	f)	Drawing up emergency plans / designation of responsible persons	Execution of risk assessment		Risk assessment	No or poor risk assessment take place
	e)	Drawing up emergency plans / designation of responsible persons	Drawing up emergency plans for all transport sections		Emergency plan	No or insufficient emergency plans drawn up
	f)	Drawing up emergency plans / designation of responsible persons	Drawing up emergency plans for all installation stages		Emergency plan	No or insufficient emergency plans drawn up
	e)	Drawing up emergency plans / designation of responsible persons	Execution of emergency practices		Emergency practices	No or insufficient training and emergency practices
	f)	Drawing up emergency plans / designation of responsible persons	Execution of emergency practices		Emergency practices	No or insufficient training and emergency practices
	f)	Planning complete: pre- / post-piling	Selection of piling method		Technology	The installation steps are appropriate for the piling technology (e.g. driving template, wrong installation equipment, etc.)

Consequences	Risk assessment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Risks are not detected and/or not analysed or wrongly assessed No conclusions to avoid risks / hazards Consequence: damage and accidents	high risk	Establish risk assessment for all installation procedures Identify correction and/or protection measures Implement correction and/or protection measures into the design, method statements, process sequences, QHSE procedures, training programmes, instructions for PPE, emergency concepts, etc. Complement / draw up a register of risks	very good	3	low risk	
As risk assessment is missing, hazards, risks, and any consequences are not detected and, therefore, no emergency measures are planned to be taken should the case occur Insufficient preparation for the handling / averting of hazardous situations	high risk	Prepare emergency plans for all transport procedures on the basis of the HAZID / HAZOP, and risk assessments carried out	very good	3	low risk	
As risk assessment is missing, hazards, risks, and any consequences are not detected and, therefore, no emergency measures are planned to be taken should the case occur Insufficient preparation for the handling / averting of hazardous situations	high risk	Prepare emergency plans for all transport procedures on the basis of the HAZID / HAZOP, and risk assessments carried out	very good	3	low risk	
Insufficient preparation and training for potential cases of emergency Staff and crews cannot cope with the situation	high risk	Prepare training plans on the basis of the emergency plans Carry out training and emergency practices on the basis of the training plans to be prepared for the case of emergency	very good	3	low risk	
Insufficient preparation and training for potential cases of emergency Staff and crews cannot cope with the situation	high risk	Prepare training plans on the basis of the emergency plans Carry out training and emergency practices on the basis of the training plans to be prepared for the case of emergency	very good	3	low risk	
Piling and installation impossible	high risk	Exactly define the piling technology and the individual steps Make external surveyors verify this	very good	3	low risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	f)	Planning complete: pre- / post-piling	Pre-piling		Pile driving template	Wrong pile driving template; does not correspond to the actually required distance between piles and pile sizes for the jacket
	f)	Planning complete: pre- / post-piling	Pre-piling		Tolerances	Tolerances for installation of jacket (installation, pile driving template, pile)
	f)	Release of installation procedures by the person in charge of project certification	Check of and release of installation procedures (method statements)		Installation procedures (method statements)	Missing or incomplete documents Faulty installation procedures that do not reflect the actual steps and sequences Wrong assumptions for design and execution
	e)	Operating manual complies with limitations	Preparing operating manuals / method statements			Wrong / poor information about restrictions for transport (e.g. weight, acceleration, weather and sea state criteria)
	f)	Operating manual complies with limitations	Preparing operating manuals / method statements		Method statements Operating manuals	Wrong / poor information about restrictions for installation (e.g. weight, acceleration, weather and sea state criteria)

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
The jacket cannot be installed Position to be rejected Ready-made / installed cables to be rejected Entire installation delayed	high risk	Use only one pile driving template Exactly mark the pile driving templates if several	very good	3	low risk	
The jacket cannot be installed Position to be rejected Entire installation delayed	high risk	Concept of limits in planning and execution	very good	3	low risk	
Delay in verification / release of the installati-on procedures Damage / accidents during transport and installation Installation infeasible due to wrong assump-tions	high risk	Select experienced certifier a) Co-ordinate the certifying process with certifier b) Early involve the certifier / MWS in the planning process Furnish proof of all valid documents (document management) Kick-off meeting on the execution of the individual transport and installation stages and check against the intended methods Check when processes are running	very good	3	low risk	
Wrong reproduction of restrictions leads to transmission of wrong information to the transport contractors / sub-contractors This entails damage or loss of the object to be transported and the transport and/or installation equipment, damage to fix and floating objects, and environmental damage	high risk	Peruse and verify the operating manuals / method statements following the six-eyes principle Discuss and verify the restriction criteria with the transport contractors / sub-contractors Make certifier / MWS verify this	very good	3	low risk	
Wrong reproduction of restrictions leads to transmission of wrong information to the installation contractors / sub-contractors This entails damage or loss of the object to be installed and the installation equipment, damage to fix and floating objects, and environmental damage	high risk	Peruse and verify the operating manuals / method statements following the six-eyes principle Discuss and verify the restriction criteria with the installation contractors / sub-contractors Make certifier / MWS verify this	very good	3	low risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	e)	Approval by MWS	Execution of a transport-relevant approval		Approval	Wrong / poor information about restrictions for installation (e.g. weight, acceleration, weather and sea state criteria)
	f)	Approval by MWS	Execution of a installation-relevant approval		Approval	Wrong / poor information about restrictions for installation (e.g. weight, acceleration, weather and sea state criteria)
	e)	Load-in/out	Identification of load-in/out method	Lift-on/off Slide on/off Roll-on/off Float-in/off Skidding	Load-in/out method	Wrong load-in/out method selected
	e)	Load-in/out	Identification of load-in/out equipment	Crane Trailer / SPMT Sliding system Skidding system Slings Upending tool Spreader beam Required class / certificate	Load-in/out equipment	Selection of improper load-in/out equipment because of wrong load-in/out method Selection of improper load-in/out equipment because of wrong weights and/or dimensions Non-compliance with requirements for class / certificates

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Damage to or loss of objects to be trans-ported Damage to fix and floating objects and environment	high risk	Contact insurance companies to ask for recommen-ded MWS companies Verify references as to sufficient experience during approval / general approval of the transport section in question Draw up a catalogue of the documents to be verified Verify certified documents, only Verify compliance with certified measures including on-site implementation In case of discrepancies, stop the approval and verify the information / measures	very good	3	low risk	
Damage to or loss of installation objects Damage to fix and floating objects and environment	high risk	Contact insurance companies to ask for recommen-ded MWS companies Verify references as to sufficient experience during approval / general approval of the installation stages in question Draw up a catalogue of the documents to be verified Verify certified documents, only Verify compliance with certified measures including on-site implementation In case of discrepancies, stop the approval and verify the information / measures	very good	3	low risk	
Loading in/out impos-sible Thus, loading in/out and entire installation delayed	medium risk	Verify basic design / detailed design Define appropriate load-in/out method Make certifier / MWS verify this	adequate	4	medium risk	
Loading in/out impos-sible Thus, loading in/out and entire installation delayed	medium risk	Verify basic design / detailed design Define appropriate load-in/out equipment Select appropriate suppliers / check of/by (AdÜ?) suppliers Make certifier / MWS verify this	adequate	4	medium risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	e)	Load-in/out	Identification of appropriate port / water terminal	Access possibilities Mooring capacities Possibilities to manoeuvre Heavy cargo pier Storage capacities Position compared to installation site Jack-up possibilities in the port (soil conditions) Cargo handling capacities	Port Water terminal	Large transport distance between manufacturer and the port of shipment / installation area Not enough moorings Poor manoeuvrability during loading, e.g. with floating crane Insufficient storage capacities Bad soil conditions to jack-up for corresponding barges / ships
	e)	Load-in/out	Identification of the requirements for the load on the pier areas for handling and storage	Surface load	Port pier of loading/ unloading Storage area	No use of port as not suitable for heavy cargo Damage to pier and access ways
	e)	Load-in/out	Identification of requirements for transport unit (barge, ship, tugboat, jack-up barge, etc.)	Loading capacity Deck surface area Stability Load on decks Ballasting Manoeuvrability	Barge Ship Tugboat Jack-up barge etc.	Poor selection of transport unit due to wrong information on the object to be transported Invalid documents on class/certification Wrong and/or inappropriate manoeuvring properties
	k)	Load-in/out	Loading and ballasting	Stowing plan	Loading and ballasting	Wrong or poor loading / ballasting during load-in/out Malfunction of ballasting system Damage to ballasting system

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Loading in/out impos-sible Thus, loading in/out and entire installation delayed	high risk	Thoroughly analyse / plan the requirements for the ports of loading/unloading On-site inspection of the ports according to the requirements Early book by contracts the port capacities	very good	3	low risk	
Loading in/out impos-sible Thus, loading in/out and entire installation delayed	high risk	Thoroughly analyse / plan the requirements for the ports and piers of loading/unloading, access ways On-site inspection of the ports according to the requirements	very good	3	low risk	
Use of transport units impossible Damage to transport unit and cargo Capsizing of transport unit due to insufficient stability and/or poor sequences of ballasting / dropping ballast Entire project delayed	medium risk	Thoroughly analyse / plan the loading and transport sections Thoroughly analyse the requirements for the ports of loading/unloading Thoroughly plan loading and transport units Prepare loading plans / method statements for each load-in/out	adequate	4	medium risk	
Transport unit will capsize Damage to transport unit and object Damage to fix and floating objects and environment Load-in/out impossible and/or entire project delayed	very high risk	Draw up a stowage and ballast plan for load-in/out - process / sequences Check and test the ballasting system prior to load-in/out Monitor the loading and ballasting sequences On-site inspection and/or take dimensions of the loading deck	very good	4	medium risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	e)	Load-in/out	Verification of class documents / certificates regarding project requirements		Barge Ship Jack-up barge etc.	No valid class documents / certificates
	e)	Load-in/out	Verification of class documents / certificates regarding the personnel	Crane driver Trainers / marshalling personnel (AdÜ? oder einweisen im Sinne von Platz zuweisen?) Operating personnel Maritime crews	Personnel	Insufficient experience how to carry out loading/unloading processes, heavy lift / offshore Lack of / insufficient communication during loading / unloading
	k)	Load-in/out	Permanent observation Verification of the weather conditions		Weather and sea state conditions	Poor weather forecast Sudden change in weather: ▪ Heavy wind, gusts ▪ Sea too rough ▪ Tide
	e)	Load-in/out	Planning and calculation of sea-fastening	Object to be transported Transport equipment Lashing methods Lashing system Loads on deck Strong points	Sea-fastening	Wrong or poor sea-fastening Safe releasing of the sea-fastening impossible when being offshore Wrong releasing of sea-fastening Damage to lashing equipment used Failure of sea-fastening
	e)	Load-in/out	Planning and calculation of grillage	Object to be transported Transport equipment Lashing methods Lashing system Loads on deck Strong points	Grillage	Damage to installed grillage Failure of grillage

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Loading in/out impos-sible Thus, loading in/out and entire project delayed	medium risk	Verify the class documents / certificates prior to any use of the units Ensure that the class documents / certificates will be valid for the entire mission or apply for new ones	adequate	4	medium risk	
Transport unit will capsize Damage to transport unit and object Damage to fixed or floating objects and environment, e.g. pier Load-in/out impossible and/or entire project delayed	high risk	Verify qualification and experience of the personnel for crane and AdÜ s.o. Draw up a loading plan with responsibilities / communication Toolbox talk prior to loading in/out	very good	3	low risk	
Loading / unloading impossible due to the weather criteria Loading / unloading delayed Loss of cargo and/ or damage to cargo / transport unit Entire project delayed	high risk	Check wether the weather reports meet the weather criteria Toolbox talk with all persons involved in the process before the respective stage starts and talk about stop criteria Monitor present weather conditions	adequate	6	medium risk	
Damage to cargo and transport means Loss of cargo or splitting of cargo and transport means Damage to fix and floating objects and environment Transport unit will capsize Towage and entire project delayed	high risk	Plan and calculate the sea-fastening on the basis of the weather conditions defined for the object to be transported and the transport equipment Implement the planning in construction Supervise the execution of construction work Prepare method statements to establish / release sea-fastening Make MWS verify and approve this	very good	3	low risk	
Damage to cargo and transport means Loss of cargo / trans-port means Damage to fix and floating objects and environment Towage and entire project delayed	high risk	Plan and calculate the grillage on the basis of the weather conditions defined for the object to be transported and the transport equipment Implement the planning in construction Make MWS verify and approve this	very good	3	low risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	e)	Load-in/out	Planning and calculation of deck structure integrity	Object to be transported Transport equipment Lashing methods Lashing system Loads on deck Strong points	Deck structure integrity	Damage to deck structure Failure of deck structure
	k)	Execution of offshore transport	Planning and calculation of deck structure integrity		Weather risk: Sudden change in weather (emergency ports and/or emergency anchoring grounds) Inaccurate forecast of wave height and wind (allowed heeling) Delay due to currents in tidal water Suddenly poor visibility	Wrong planning (safe-to-safe periods, duration of procedures, speeds) Wrong / inaccurate weather forecast Poor site investigations of emergency ports / emergency anchoring grounds
	l)	Execution of offshore installation	Planning and calculation of deck structure integrity		Weather risk: Sudden change in weather (emergency ports and/or emergency anchoring grounds) Inaccurate forecast of wave height and wind (allowed heeling) Delay due to currents in tidal water Suddenly poor visibility	Wrong planning (safe-to-safe periods, duration of procedures, speeds) Wrong / inaccurate weather forecast Poor site investigations of emergency ports / emergency anchoring grounds

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Damage to cargo and transport means Loss of cargo / trans-port means Damage to fix and floating objects and environment Towage and entire project delayed	very high risk	Evidence of allowed loads on deck, structures, lashing points according to SOLAS (Cargo Securing Manual) Proof by calculation of the loads resulting from cargo, grillage, and sea-fastening Verification and approval on site by MWS	very good	4	medium risk	
Damage to ship and/or cargo (foundation) Risk of life and limb (HSE) Transport processes delayed	high risk	Weather forecast from two independent forecasting services Thoroughly plan the emergency concept (incl. safe-to-safe periods) and make an independent surveyor or certifier verify this early Plan the logistics (transport processes) to comply with industrial standards (e.g. DNV-OSH101, GL, ISO 19901-6, LOC)	very good	3	low risk	
Damage to ship and/or cargo (foundation) Risk of life and limb (HSE) Installation procedures delayed	high risk	Weather forecast from two independent forecasting services Thoroughly plan the emergency concept (incl. safe-to-safe periods) and make an independent surveyor or certifier verify this early Plan the logistics (installation processes) to comply with industrial standards (e.g. DNV-OSH101, GL, ISO 19901-6, LOC)	very good	3	low risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	k)	Execution of offshore transport	Planning and calculation of deck structure integrity		Technical failure of a transport unit	Technical damage to transport unit
	l)	Execution of offshore installation	Planning and calculation of deck structure integrity		Technical failure of an installation unit	Technical damage to installation unit
	k)	Execution of offshore installation	Planning and calculation of deck structure integrity		Collision with other ships or other fixed or floating objects	Collision with other ships or other fixed or floating objects ▪ Technical failures ▪ Poor co-ordination, e.g. collision of heavy equipment vehicles ▪ Poor navigation, e.g. a ship not involved in the construction runs into the construction site ▪ 4) Human failure
	l)	Execution of offshore installation	Planning and calculation of deck structure integrity		Collision with other ships or other fixed or floating objects	Collision with other ships or other fixed or floating objects ▪ Technical failures ▪ Poor co-ordination, e.g. collision of heavy equipment vehicles ▪ Poor navigation, e.g. a ship not involved in the construction runs into the construction site ▪ Human failure

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
No transport units, incl. drifting off, grounding, capsizing, sinking or loss possible Unit to be replaced Transport and entire project delayed	medium risk	Select well-respected, experienced, and certified transport companies (ISO, ISM, IMCA) Early draw up a condition survey of the units and equipment used to find adequate replacement where necessary Permanent monitoring Contingency plans for failures Access to stand-by tugboats Toolbox meetings	adequate	4	medium risk	
No installation units, incl. drifting off, grounding, capsizing, sinking or loss possible Unit to be replaced Installation and the entire project delayed	medium risk	Select well-respected, experienced, and certified installation companies (ISO, ISM, IMCA) Early draw up a condition survey of the units and equipment used to find adequate replacement where necessary Permanent monitoring Contingency plans for failures Access to stand-by tugboats Toolbox meetings	adequate	4	medium risk	
Structural damage to transport unit Water inrush, capsizing, sinking, or loss of transport unit Damage to fix and floating objects and environment and persons (HSE) Transport and entire project delayed Damage to foundations	medium risk	Plan and supervise processes and exact route Comply with COLREGs (e.g. day and night signals) Use a guard-boat Warn other ships that there are exceptional transports Emergency plans Access to stand-by tugboats Use the Sea Surveillance Marking / buoyage of the construction field Where required, use DP systems Work done by qualified personnel	adequate	4	medium risk	
Structural damage to installation unit Water inrush, capsizing, sinking, or loss of installation unit Damage to fix and floating objects and environment and persons (HSE) Installation and the entire project delayed Damage to foundations	medium risk	Plan and supervise processes and exact route Comply with COLREGs (e.g. day and night signals) Use a guard-boat Warn other ships that there are exceptional installation procedures Emergency plans Access to stand-by tugboats Use the Sea Surveillance Marking / buoyage of the construction field Where required, use DP systems Work done by qualified personnel	adequate	4	medium risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	k)	Execution of offshore transport	Planning and calculation of deck structure integrity		Taking the ground	Taking the ground: ▪ Technical failures ▪ Poor co-ordination ▪ Poor navigation ▪ Human failure ▪ Poor knowledge of under-keel clearance / draught and/or cargo
	l)	Execution of offshore installation	Planning and calculation of deck structure integrity		Taking the ground	Taking the ground: ▪ Technical failures ▪ Poor co-ordination ▪ Poor navigation ▪ Human failure ▪ Poor knowledge of under-keel clearance / draught and/or cargo
	k)	"Execution of offshore transport"	Planning and calculation of deck structure integrity		Fire	Fire: ▪ Technical failures / defects ▪ Collision ▪ Improper execution of activities (e.g. welding) ▪ Human failure ▪ Handling of open fire
	l)	Execution of offshore installation	Planning and calculation of deck structure integrity		Fire	Fire: ▪ Technical failures / defects ▪ Collision ▪ Improper execution of activities (e.g. welding) ▪ Human failure ▪ Handling of open fire

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Water inrush, capsi-zing, sinking, or loss of transport unit Damage to transport unit Damage to fix and floating objects and environment Transport and entire project delayed Damage to footing structures	medium risk	Plan and supervise exact route Emergency plan and emergency measures accor-ding to SMS / ISM	adequate	4	medium risk	
Water inrush, capsi-zing, sinking, or loss of transport unit Damage to transport unit Damage to fix and floating objects and environment Transport and entire project delayed Damage to footing structures	medium risk	Plan and supervise exact route Emergency plan and emergency measures accor-ding to SMS / ISM	adequate	4	medium risk	
Structural damage to installation unit Water inrush, capsi-zing, sinking, or loss of installation unit Damage to fix and floating objects and environment Installation and the entire project delayed Damage to / loss of foundation	medium risk	Structural and mobile fire alarm and fire extingu-ishing systems according to SOLAS Permanent monitoring of the fire alarm systems Emergency plans according to SMS / ISM	adequate	4	medium risk	
Structural damage to installation unit Water inrush, capsi-zing, sinking, or loss of installation unit Damage to fix and floating objects and environment Installation and the entire project delayed Damage to / loss of foundation	medium risk	Structural and mobile fire alarm and fire extingu-ishing systems according to SOLAS Permanent monitoring of the fire alarm systems Emergency plans according to SMS / ISM	adequate	4	medium risk	

9.6

Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
k)	Execution of offshore transport	Equipment for loading		Unsuitable cranes / equipment	Equipment changed Not in the plans
e)	Execution of offshore transport	Identification of load-in/out objects	Weights dimensions	Loaded object	Wrong weight information (no weight check during assembly) Wrong dimensions (no final object dimensions taken)
k)	Execution of offshore transport	Suitability of the port for jacking		Jacking	Inadequate building ground Poor investigation Considerable preload (previous jacking)
k)	Execution of offshore transport	Verification of class documents / certificates regarding project requirements		Barge Ship Jack-up barge etc.	No valid class documents / certificates
k)	Execution of offshore transport	Verification of class documents / certificates regarding the personnel	Crane driver Trainers / marshalling personnel (AdÜ? oder einweisen im Sinne von Platz zuweisen?) Operating personnel Maritime crews	Personnel	Insufficient experience how to carry out loading/unloading processes, heavy lift / offshore Lack of / insufficient communication during loading / unloading
k)	Execution of offshore transport	Sea-fastening		Sufficient sea-fastening	Poor planning Poor ship, barge, etc. Poor execution
k)	Execution of offshore transport	Sea-fastening		Towrope	Towrope damaged / broken

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Loading impossible or delayed	high risk	Verify the class documents / certificates prior to any use of the units Closely co-ordinate planning and execution	very good	3	low risk	
Load-in/out impossible; thus, delayed load-in/ out as well as entire installation	medium risk	Weight monitoring Dimensions to be taken upon completion by certi-fied company Draught survey Make certifier / MWS verify this	adequate	4	medium risk	
Damage to transport unit (e.g. punch through etc.) Load-in/out impossible and/or entire project delayed Damage to port (wharf)	high risk	Soil investigation Where required, take actions to improve the ground Jacking tests	very good	3	low risk	
Load-in/out impossible; thus, load-in/out and entire project delayed	medium risk	Verify the class documents / certificates prior to any use of the units Ensure that the class documents / certificates will be valid for the entire mission or apply for new ones	adequate	4	medium risk	
Transport unit will capsize Damage to transport unit and object Damage to fixed or floating objects and environment, e.g. pier Load-in/out impossible and/or entire project delayed	high risk	Verify qualification and experience of the personnel for crane and AdÜ s.o. Draw up a loading plan with responsibilities / communication Toolbox talk prior to loading in/out	very good	3	low risk	
Loss of or damage to barge / ship or founda-tion structure	high risk	Verify the class documents / certificates prior to any use of the units Certification of sea-fastening Acceptance / inspection of sea-fastening	very good	3	low risk	
Drifting off, grounding, capsizing, sinking, or loss of barge possible Damage to fix and floating objects and environment Towage and entire project delayed	medium risk	Use adequate towing gear according to correspon-ding standards (DNV, GL ND) on the basis of the calculated capacities to be towed Install redundant towing gear (emergency gear)	adequate	4	medium risk	

9.6

Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
k)	Execution of offshore transport	Sea-fastening		Duration	Selection of route Tide currents or weather conditions Towing speed Conditions by public law (AdÜ: ?) Poor planning
l)	Execution of offshore installation	Sea-fastening		Co-ordination	Work stopped, completion uncertain: - Poor co-ordination of activities left to be done - Poor or missing emergency plans - Obscure procedure, missing responsibilities - Poor definition of limitations of use - Decision by master / MWS - Technical failures
l)	Execution of offshore installation	Stability during construction	Installation of footing structure not yet complete whilst the weather is changing	Weather risk	Technical failures / failures during installation Poor weather forecast Planned time too short Poor planning
k)	Positioning Mooring DP	Stability during construction		DP system fails	Technical failure Improper use Use beyond limitation of use
k)	Positioning Mooring DP	Dynamic positioning of: ▪ crane vessel ▪ tugboat ▪ AHT ▪ supply vessel ▪ jack-up vessel		Malfunction of DP system during installation:	no DP trail load distribution on the ship non-observance of limitations of use malfunction of sensors / measuring error Technical failure

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Transport and instal-lation and/or entire project delayed Change in weather Co-ordination of activities	high risk	Make experienced experts establish a solid planning Early notify / involve the traffic control centre Use two independent weather services Deeply analyse the transport procedure	very good	3	low risk	
Structural damage to tugboat / transport and/ or installation unit Damage to foundations Installation / entire project delayed Risk of life and limb Obscure procedures and/or responsibilities unclear	high risk	Planning: HAZOP study and risk analysis incl. development of corresponding emergency plans Work done by qualified personnel Prior to operation toolbox meeting of anyone invol-ved in the process with stop criteria and responsi-bilities	very good	3	low risk	
Stability of the footing structure not given Damage to footing structure Damage to equipment	high risk	Solid planning of offshore operations Weather report from two independent services Analyse the conditions on-site Have the plannings and procedures certified	very good	3	low risk	
Impossible to lower into water / install the system Pile installation work and entire project delayed	medium risk	Select well-respected, experienced, and certified tugboat companies (ISO, ISM, IMCA) Early draw up a condition survey of the units and equipment used to find adequate replacement where necessary Qualified and trained crew Contingency plan for lack of tugboats / supply vessels (ISM) Access to stand-by tugboats / supply vessels	adequate	4	medium risk	
Maritime units drifting during installation Collision with fixed and floating objects / items Damage to objects / items Installation delayed	medium risk	Carry out maintenance work as required by the manufacturer Check all units for their use in the field DP trail prior to starting any work Use qualified and trained personnel for operation and maintenance	very good	2	low risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	k)	Positioning Mooring DP	Dynamic positioning of: ▪ Crane vessel ▪ Tugboat ▪ AHT ▪ Supply vessel ▪ Jack-up vessel		Weather and sea state conditions	Heavy wind, gusts Sea too rough Tide
	l)	Bubble curtain to reduce the propagation of hammering sound (relieved foundation systems / monopiles)	Use of bubble curtain system		Bubble curtain system	Failure and loss of the system
	l)	Bubble curtain to reduce the propagation of hammering sound (relieved foundation systems / monopiles)	Use of bubble curtain system		Weather and sea state conditions	Heavy wind, gusts Sea too rough Tide
	l)	Jacking	Check of trimming/ heeling level for jacking		Trimming/ heeling level	Too much trimming/ heeling of installation vessel
	l)	Jacking	Jacking down and make the legs stable		Missing stability	Fault of jack-up system Varying depth of penetration of the legs Inhomogeneous soil Monolithes Already several jacking procedures at this location
	l)	Jacking	Enough distance between the bottom platform edge and maximum wave height		Sufficient jacking capacity	Loading of jack-up vessel/barge Soil / penetration of legs Poor analysis of max. wave height

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Impossible to reach or keep position	high risk	Define appropriate weather criteria Verify the weather report (two independent weather services) Carry out operations under defined weather conditions / in defined weather slot, only	very good	3	low risk	
No sound-reducing measures possible Pile installation work and entire project delayed	medium risk	Maintain and inspect the system prior to any use Redundant system Spare parts Skilled and trained personnel	adequate	4	medium risk	
Impossible to build up bubble curtain and, consequently, the latter is ineffective Pile installation work and entire project delayed	medium risk	Define appropriate weather criteria Check the weather reports Carry out operations under defined weather conditions only	adequate	4	medium risk	
Jacking impossible Jacking and installation process delayed	high risk	Exactly plan, calculate, and execute the process Design accordingly to minimise ballasting Take required ballast into account when designing the jacking system Use pump systems for ballasting (if required)	very good	3	low risk	
Jacking impossible Damage to legs Jacking and installation process delayed	very high risk	Use of certified systems and experienced companies, only Exactly plan, calculate, and design the jacking system (e.g. sufficient safety margins, suitable for offshore use) Make qualified personnel of the supplier of the jacking system operate the system Redundancy of jacking system components as far as possible Tests Geotechnical investigations Prior to operation toolbox meeting of anyone involved in the process with stop criteria and responsibilities	adequate	8	high risk	
Jacking impossible Damage to barge by slamming Damage to legs Jack-up and installation delayed	high risk	Geotechnical investigations Verify the weather report Exactly plan jacking	very good	3	low risk	

9.6

Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
l)	Jacking	Observance of weather and sea state criteria		Weather and sea state conditions	Heavy wind, gusts Sea too rough Too strong currents in the different depths of water
l)	Lifting procedure	Fastening the spreader	Slings Shackles etc.	Load-in/out equipment	Selection of improper load-out equipment because of wrong load-out method Selection of improper load-out equipment because of wrong weights and/or dimensions Load-out equipment defective No appropriate fastening points
l)	Lifting procedure	Release of sea-fastening		Sea-fastening	Lifting of the foundations to completely release the sea-fastening Sea-fastening under load (AdÜ?) Thus, sea-fastening becomes released before it will be completely disconnected
l)	Lifting procedure	Lifting procedure		Crane ship Installation unit	Damage to crane ship (e.g. damage to the windscreen of the crane, twisting of the crane rope, damage to the crane rope as it runs over sharp edges, damage to the boom due to contact with the foundation, etc.)

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Jacking impossible Damage to barge by slamming Damage to legs Jack-up and installation delayed	high risk	Check wether the weather reports meet the weather criteria Exactly plan jacking Monitor present weather conditions	very good	3	low risk	
Impossible to load out Touch up the design Lifting and installation of topside delayed	medium risk	Exactly plan lifting Calculate and design the foundations so as to suit lifting Provide the foundations with suitable, certified fastening points Select suitable spreader with certifications Select appropriate suppliers / check of/by (AdÜ?) suppliers Make certifier / MWS verify this Visually inspect the spreader prior to any use	very good	2	low risk	
Damage to and/or loss of foundations, crane ship, barge, spreader	medium risk	Exactly plan disconnection of sea-fastening Draw up corresponding plan (exact releasing sequence for sea-fastening, use of tools, safety measures to be taken, etc.) Toolbox meeting before taking action Use of experienced personnel Use of appropriate tools Protect the foundations against damage and/or loss (e.g. fasten the crane before disconnection of the sea-fastening) Monitor disconnection	very good	2	low risk	
Damage to and/or loss of foundation Lifting and, conse-quently, installation of foundations delayed due to failure of the crane ship	high risk	Select a suitable crane ship for lifting Check the class and other certificates (among other things crane certificates of class and test reports) Check whether maintenance and test intervals have been observed Carry out visual inspection and function test prior to any use	adequate	6	medium risk	

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Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
l)	Lifting procedure	Lifting procedure (lifting and depositing)		Lifting	Swinging, twisting, and slamming of foundations (slamming = Aufschlagen des Schiffsbodens auf die Wasseroberfläche bei Seegang AdÜ?) Uneven load distribution: ▪ Lifting: (centre of gravity far beyond vertical axis of foundation) ▪ Depositing: touching down onto the foundation / pile or other structures
l)	Lifting procedure	Observance of weather and sea state criteria		Weather and sea state conditions	Heavy wind, gusts Sea too rough Too strong currents in the different depths of water
l)	Setting down the base structure onto the seabed	Positioning of foundation on the seabed (pre-piling) (under water)		Pile position	Wrong setting down Impossible to position the foundation due to wrong piling Accuracy of piles / distances Damage to piles (e.g. by ships, sanding up, due to installation) Failure of positioning system (computer, GPS, etc.)
l)	Setting down the base structure onto the seabed	Positioning of foundation on the seabed (post-piling) (under water)	Tolerances	Final position	Final position not within required limits Failure of positioning system (computer, GPS, etc.)

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Falling of the spreader from the hooks Damage to the founda-tions, the crane ship, the barge, and/or other structures due to contact / collision with the topside,	high risk	Use experienced and qualified crane drivers Toolbox meeting before taking action to define (AdÜ) stop criteria Take safety measures to prevent swinging, rotating of the foundations (e.g. tug ropes and tug winches) Take safety measures on the hook to prevent falling of the spreader from the hooks Make the supervisor monitor the lifting procedure	adequate	6	medium risk	
Lifting impossible Lifting and, thus, entire installation delayed	high risk	Check wether the weather reports meet the weather criteria Exactly plan lifting Monitor present weather conditions	adequate	6	medium risk	
Re-lifting/-jacking of the foundation and new attempt to position it within limits Possible damage to foundation or piles Due to wrong piling installation position to be turned down Required repair actions on the piles Installation and entire project delayed	medium risk	Take exact dimensions of pile positions for installa-tion of the foundation (after piling, before installa-tion) Develop a method to set down and exactly position the foundation Select suitable measuring instruments and monito-ring equipment Monitor setting down of the foundation and perma-nently check the actual against the desired position If required, lift the foundation again and restart positioning Redundancy of systems	very good	2	low risk	
Re-lifting/-jacking of the foundation and new attempt to position it within limits Installation and entire project delayed No exact positioning of the foundation above piles Damage to piles / foundation Installation and the entire project delayed	medium risk	Develop a method to set down and exactly position the foundation Select suitable measuring instruments and monito-ring equipment Monitor setting down of the foundation and perma-nently check the actual against the desired position If required, lift the foundation again and restart positioning Use different measuring systems Redundancy of systems Engineers on site who know the systems	very good	2	low risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	l)	Alignment of footing structure	Alignment of the foundation during installation (under water)	Defined alignment of the foundation Subsoil expertise (foundation type: gravity structure, suction bucket) Marking Pull-in of cable Alignment of landing	Final position	Wrong alignment of the structure during installation Poor surveying of the structure
	l)	Alignment of footing structure	Alignment of transition piece (monopile) (surface)		Alignment	Seabed / piles not levelled out (even) within the required limits Foundation not aligned within the required limits (horizontal and quarter) Alignment mechanisms of insufficient dimensions Poor concept of allowable variations
	l)	Alignment of footing structure		Cameras ROV Shock absorber	Underwater guiding / positioning aids	Failure of and/or damage to the guiding / positioning aids
	l)	Alignment of footing structure	Weather and sea state criteria		Weather and sea state conditions	Heavy wind, gusts Sea too rough Too strong currents in the different depths of water
	l)	Floating installation unit	Heaving Shock load			Vertical movement due to sea state

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Stability or installation problems possible Marking to be changed Additional expenditure for cable connection Reduced accessibility Damage due to diffe-rent soil Access system mislo-cated Cable pull-in misaligned Marking misaligned	medium risk	Thoroughly plan installation / installation position Toolbox meeting Take exact dimensions of pile position Quality control during installation Work with experienced personnel Mark clearly and check the alignment	very good	2	low risk	
The foundation is out of limits Re-lifting and new attempt to position it within limits Seabed to be evened out / height adjustment of foundations Installation and entire project delayed	high risk	Have soil surveys drawn up Where required and possible take improving measures (excavation, levelling layers) and/or use levelling technology Take reading of alignment after setting down of the foundation on the seabed Level by application of corresponding pile method	very good	3	low risk	
Impossible to insert the legs into the foundation as a consequence of the failure of and/or damage to the guiding/ positioning aids Jacking and installation process delayed	medium risk	Exactly plan how to insert the legs and use appro-priate guiding and positioning aids (suitable for underwater use, shock-resistant, etc.) Redundancy of systems (where possible) Make only qualified personnel operate the system Prior to operation toolbox meeting of anyone invol-ved in the process with stop criteria and responsi-bilities	very good	2	low risk	
Exact positioning impossible	high risk	Check wether the weather reports meet the weather criteria Plan positioning exactly Monitor present weather conditions	adequate	6	medium risk	
Uncontrolled impact of the foundation onto the seabed / piles	medium risk	Observe the weather criteria Work with qualified personnel	very good	2	low risk	

9.6

Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
l)	Pulling in	Pulling cable into the foundation	Pull-in cable	Pull-in cable not ready for operation or breaking	Pull-in cable breaking Pull-in cable not pulled into J-tube or get lost during pulling in
l)	Connection to wind turbine	Fastening of the cable in the foundation Connection to wind turbine	Permanent cable fastening	Cable insufficiently fastened	Cable becomes loose or damaged Suspension damaged Poor fastening
l)	Connection to wind turbine	Cable connection		Not enough space Bending radius insufficiently considered	Pulling in and fastening
l)	Foundations on seabed	Driving-in of piles	Pre-piling Post-piling	Piles	Piles' bearing capacity not as required
l)	Foundations on seabed	Driving-in of piles	Vibro/hydraulic hammer	Equipment	Failure due to technical fault of vibro/hydraulic hammer
l)	Foundations on seabed	Driving-in of piles		Sea ground	Unexpected seabed conditions, rocks and other objects

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Problems in the following Cable perhaps to be salvaged Damage to cable Pull-in cable to be installed, to be pulled in again	very high risk	Thoroughly plan pulling in of cables Quality control during manufacture Co-operate with experience offshore companies	very good	4	medium risk	
Damage to cable and/or suspension Connection / commissi-oning delayed	medium risk	Sufficiently dimension the cable suspension Work with experienced personnel when pulling in / fastening the cable	very good	2	low risk	
Damage to cable Impossible to install the cable Pulling in of cable / mains connection delayed	medium risk	Sufficiently plan / dimension the cable basement Co-operate with experience offshore companies	very good	2	low risk	
Impossible to drive in the pile at all or down to the planned depth Damage to / destruc-tion of pile (Pile to be rejected as not useful anymore) Loss of pile as stuck in the seabed; to be cut Possibly, position to be rejected	high risk	Soil investigations / expert opinions on geophysical characteristics Make expert in geophysics verify the results Draw up a driving study Define the driving force and use this to define the vibro/hydraulic hammer Design the piles corresponding to the results of the soil survey and driving study Use the piles required for the corresponding pile position and the corresponding vibro/hydraulic hammer Carry out and supervise the piling work by person-nel experienced in this field	very good	3	low risk	
Installation and driving work delayed Damage to piles or the pile driving template Premature refusal	high risk	Redundancy of hammers Engineer(s) and spare parts on site	very good	3	low risk	
Impossible to reach the required depth of penetration Driving impossible Pile position to be rejected Project delayed	high risk	Soil investigations / soil survey (borehole logs, core penetration tests, soil scans) Geophysical and geotechnical investigations	adequate	6	medium risk	

9.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	l)	Foundations on seabed	Driving-in of piles		Sound Noise	The sound under water exceeds the BSH limits
	l)	Foundations on seabed	Weather and sea state criteria		Weather and sea state conditions	Heavy wind, gusts Sea too rough Too strong currents in the different depths of water
	f)	Grouting monopiles Transition piece and pile Relieved structure	Selection of grouting material		Grouting material	Wrong selection of grouting material Physical properties do not suit the planned use
	l)	Grouting monopiles Transition piece and pile Relieved structure	Use and manipulation of grouting material		Grouting material	Too short hardening times before exerting any stress onto the grouted structure Non-observance of operating temperatures
	l)	Grouting monopiles Transition piece and pile Relieved structure	Use of grouting equipment		Grouting equipment	Fault of grouting equipment Blocking and choking of grout pipes/hoses

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Damage to marine animals	high risk	Take sound-reducing measures (box dam, bubble curtain, etc.) Frighten marine mammals away of the installation area Take readings proving compliance with allowed sound level and that marine mammals have been frightened away (e.g. POD)	adequate	6	medium risk	
Piling of foundation impossible Project delayed	high risk	Check wether the weather reports meet the weather criteria Exactly plan piling Monitor present weather conditions Sturdy equipment	adequate	6	medium risk	
Grouted structure does not prove sufficient strength and, thus, its durability is insufficient Damage to grouted structure and total strength of structures Grouting and installati-on delayed	very high risk	Select experienced and certified grouting compa-nies Select and use certified grouting material according to the specifications Monitor grouting and examine grout samples Consent by BSH	very good	4	medium risk	
Grouted structure does not prove sufficient strength and, thus, its durability is insufficient Damage to grouted structure and total strength of structures Grouting and installati-on delayed	high risk	Select experienced and certified grouting compa-nies Select and use certified grouting material according to the specifications Monitor manipulation of the grout under the required ambient conditions and examine ground samples	very good	3	low risk	
Damage to grouted structures or grouting equipment and total strength of structures Grouting and installati-on delayed	high risk	Select experienced and certified grouting compa-nies Select and use of reliable grouting equipment Redundancy Make engineer(s) of the grouting company operate the equipment Engineer(s) and spare parts on site Toolbox meeting before taking action Monitoring of grouting process Immediately clean equipment / pipes and hoses prior to longer downtimes	adequate	6	medium risk	

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Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
l)	Grouting monopiles Transition piece and pile Relieved structure	Examine and release grouted structure		Grouted structure	Grouted structure released too early and without any check
l)	Alignment of structure (Transition piece, relieved structure)	Verticality of wind turbine		Alignment	Poor alignment and fastening Poor tolerances Poor grouting procedure
l)	Alignment of structure (Transition piece, relieved structure)	Weather and sea state criteria		Weather and sea state conditions	Heavy wind, gusts Sea too rough Too strong currents in the different depths of water Temperatures too low
l)	Admitting of scouring	Admitted scouring	Defined scouring admitted	Strong scouring	Scouring underestimated Poor consideration in planning Poor dimensioning
l)	Installation	Installation of scour protection	Prompt installation	Missing scour protection	Sequences delayed Weather restrictions Machine failures
l)	Installation	Installation of scour protection	Method	Damage to foundation	Improper installation Unsuitable scour protection
l)	Installation	Installation of scour protection		Incomplete scour protection	Improper installation
l)	Execution of offshore installation	Integrity of scour protection		Damage to scour protection	Laying of cables Anchor Jacking

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Grouted structure does not prove sufficient strength and, thus, its durability is insufficient Damage to grouted structures and total strength of structures	medium risk	Select experienced and certified grouting compa-nies Select and use certified grouting material according to the specifications Monitor manipulation of the grout under the required ambient conditions and examine ground samples	very good	2	low risk	
Wind turbine not vertical Damage to wind turbine Subsequent work Re-alignment Construction / project delayed	high risk	Work with experienced personnel Prepare solid concept of allowable variations Monitor the verticality	very good	3	low risk	
Impossible to carry out grouting Grouting and installati-on delayed Premature load onto grouted structure	high risk	Check wether the weather reports meet the weather criteria Exactly plan grouting Monitor present weather conditions Sturdy equipment	adequate	6	medium risk	
Inadmissible scouring / not planned Perhaps additional scour protection Stability at risk	high risk	Take admissible scouring sufficiently into account for the design Make random checks how scouring develops Detailed site survey Simulate the flow conditions	adequate	6	medium risk	
Risk of not planned scouring Perhaps touch-up work required	high risk	Use two independent weather services Sufficiently analyse the initial scouring Promptly install a scour protection	very good	3	low risk	
Damage to foundation structure (e.g. the surfaces)	medium risk	Select a suitable scour protection Select an appropriate procedure to install the scour protection	adequate	4	medium risk	
Inadmissible scouring Damage to foundation Project delayed due to touch-up work	medium risk	Check the scour protection after installation Work with experienced offshore company	adequate	4	medium risk	
Damage to scour protection Stability at risk	medium risk	Work with a co-ordinator of vehicles Work with experienced personnel Thoroughly plan laying of cables	adequate	4	medium risk	

9.6

Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
l)	Execution of offshore installation	Integrity of scour protection		Drive	Tools do not work properly (functionality of tools not given) Driving forces exceed designed capacity Unsuitable tools Failure of ILT / gripper vs. connection of monopiles
k)	Transport	Integrity of scour protection			Floating monopiles: faulty design of plugs Barge: damage to corrosion protection by sea-fastening (e.g. corrosion protection at welds of transition pieces)

Legend
a) Execution planning of soil investigation for locations of offshore wind turbines
b) Soil investigation for locations of offshore wind turbines
c) Execution planning of the inland transport (overland and rivers) from the factory to the offshore port
d) Execution planning of the storage in the offshore port and the onshore assembly there
e) Execution planning of offshore transports
f) Execution planning of offshore erection
g) Execution planning of residual assembly work offshore
h) Execution planning of the commissioning and the test run until getting the PAC
i) Inland transport (overland and rivers) from the factory to the offshore port
j) Storage in the offshore port and the onshore assembly there
k) Offshore transports
l) Offshore erection
m) Residual assembly work offshore
n) Commissioning and test run until getting the PAC

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.6
Damage to monopi-le / equipment (e.g. hammer, sleeve, vessel) Works delayed Damage to pile tip	medium risk	Use higher rated hammer/spare capacity Have spare parts on field or redundant equipment (2. hammer) Work with skilled personnel	very good	2	low risk	
Damage to or loss of monopile Damage to corrosion protection	high risk	QM in design, preparation, and procedure of the plugs Exactly define operating procedures for sea-faste-ning	adequate	6	medium risk	

9.7 Erection of tower, nacelle, and rotor

9.7.1 Planning of the erection of WTG

9.7.1	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore transports	Planning of offshore erection of wind turbine	Planning and assignment of the transports of the wind turbine offshore	Load-out	Availability / suitability of quayside for storage of WTGs Availability / suitability of quayside to moor a vessel / barge alongside
	Execution planning of offshore erection	Planning of offshore erection of wind turbine	Planning and reservation of reserve capacities for offshore erection Personnel	Inexperience	Lack of experienced personnel endangers the workability and safety for the performance of the work (Due to shortage, there is a lack of experienced personnel)
	Execution planning of offshore erection	Planning of offshore erection of wind turbine	Planning and reservation of reserve capacities for offshore erection Personnel	Availability	Lack of engineering workforce
	Execution planning of offshore erection	Planning of offshore erection of wind turbine	Planning and reservation of reserve capacities for offshore erection Ships	Inexperience	Lack of experience of contractor / ship (there is a number of new contractors on the market with limited experience)
	Execution planning of offshore erection	Planning of offshore erection of wind turbine	Planning and reservation of reserve capacities for offshore erection Ships	Availability	Not enough ships for planned number of projects Offshore oil and gas is picking up the coming years, putting more pressure on the vessel availability
	Execution planning of offshore erection	Planning of offshore erection of wind turbine	Planning and reservation of reserve capacities for offshore erection Ships	Weight	Lift limitations of vessels
	Execution planning of offshore erection	Planning of offshore erection of wind turbine	Planning and reservation of reserve capacities for offshore erection General	Planning	If the planning is too tight (just-in-time planning), a delay to one operation causes a huge impact on the remaining / other operations

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.7.1
Delays Cost overrun Schedule impact	medium risk	Work with skilled personnel Feasibility study of quayside / storage location Ensure early involvement of potential contractors (make sure you allow for alternatives at the early stage)	very good	2	low risk	
Danger to the safety performance of the project resulting in damage to or loss of structures, or injury or death of personnel	high risk	Involve expertise of contractors and 3rd party agencies Where possible, try to use known successful technologies and systems Use standardisation on a project	adequate	6	medium risk	
Schedule, safety, and damage risk	high risk		adequate	6	medium risk	
Danger to the safety performance of the project resulting in damage to or loss of structures, or injury or death of personnel	high risk	Use certified vessels Contractors without a successful track-record have to do a test run first Use of multiple contractors (split the work) Implement long term relationships (strategic partners)	adequate	6	medium risk	
Delays due to lack of vessels and prices for ships are increasing	medium risk	Plan ahead and start reserving / contracting vessels at an early stage Implement / use of additional contingency budget for vessel cost overruns if you do not secure them at an early stage	very good	2	low risk	
The higher the weight, the less number of ships can perform the work, the more pressu-re is on availability	medium risk	Account for alternative installation methods early in order not to run into difficulties with the BSH approvals Perform feasibility study on the vessel Ensure reserve capacity in the installation tolerances of the vessels used	very good	2	low risk	
Schedule, consequen-tial standby costs, availability of vessels after a prolonged delay, additional "recovering" cost	high risk	Create a gap between fabrication and installation time to build up sufficient spare capacity to allow for delays Early start of offshore operations in order to also create gaps between linked offshore construction works (i.e. foundation installation versus cables, etc.) - from a holistic point of view on all processes Set the liabilities to the contractor such that on time delivery is key and encouraged Set-up interface communication within the whole supply chain	adequate	6	medium risk	

9.7.1	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of offshore erection	Planning of offshore erection of wind turbine	Planning and reservation of reserve capacities for offshore erection Devices	On-shore assembly	In case of floating crane concept, the mast, the nacelle, and potentially the blades are assembled on-shore The cranes and foundation(s) required for this approach in combination with a suitable yard need to be assured
	Execution planning of offshore erection	Planning of offshore erection of wind turbine	Planning and reservation of reserve capacities for offshore erection Devices		Turbines getting bigger and heavier
	Execution planning of offshore erection	Planning of offshore erection of wind turbine	Involve the project certifier and MWS for offshore erection and make them check it	Delay	No availability of (experienced/qualified) MWS

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.7.1
Delays due to unavai-lability of equipment or yard capacity	medium risk	Involve the contractor at an early stage Feasibility study / site surveys	very good	2	low risk	
Errors in calculating quayside requirements (having greater impact due to size and weight increase)	medium risk	Full engineering checks and suitability surveys	very good	2	low risk	
	medium risk	Start contracting these services at an early stage Work together with other wind developers to train MWS on other projects (working together with experienced MWS)	very good	2	low risk	

9.7 Erection of tower, nacelle, and rotor

9.7.2 Planning of loading and sea transport

9.7.2	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Execution planning of inland transport	Planning of loading and sea transport	Route planning incl. alternative ports	Load-out	Availability / suitability of quayside for storage of WTGs (alternative ports) Availability / suitability of quayside to moor a vessel / barge alongside and the route, including accessibility (like bridges, logs, etc.) Lack of engineering input for transport and installation Damage to components during load-out and transportation
	Execution planning of inland transport	Planning of loading and sea transport	Planning of emergency ports (shelter)	Inefficiency	Having close-by sheltered area to use for standby during weather downtime
	Execution planning of inland transport	Planning of loading and sea transport	Clear up allowed sea state and weather conditions with MWS / certifier Make the MWS check, accept, and permit the transport planning	Timing	MWS / certification body does not approve the documents Realistic requirements to allow practical installation methods, whilst maintaining strength and warranty of the WTGs
	Execution planning of inland transport	Planning of loading and sea transport	Clear up whether MWS will be available during transport	Timing	MWS / certification body does not approve the documents Realistic requirements to allow practical installation methods, whilst maintaining strength and warranty of the WTGs
	Execution planning of inland transport	Planning of loading and sea transport	Vessel requirements	Unsuitability	Offshore requirements not met Turbines getting bigger and heavier Man overboard procedures inadequate
	Execution planning of inland transport	Planning of loading and sea transport	Draw up emergency plans Designate responsible persons	Damage / injury	No clarity on emergency procedures or unaligned procedures between the several contractors

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.7.2
Delays, cost overruns Incorrect rigging Sea-fastening design of load-out equipment inadequate	medium risk	Feasibility study Allow for alternatives from the beginning Experienced offshore engineers to be recruited at an early stage and/or early involvement of the installation contractor	very good	2	low risk	
HSE risk or large distance sailing delaying the work	medium risk	If no sheltered area is close-by, include sufficient budget and time for consequence	very good	2	low risk	
Delays as changing these types of documents absorbs a lot of time Errors in these documents may result in damage and conse-quential delays	high risk	Early involvement of both MWS and experienced contractors Use certified vessels Detailed planning of installation procedures Interface management between designer, manufac-turer, and installation companies	very good	3	low risk	
Delays as changing these types of documents absorbs a lot of time Errors in these documents may result in damage and conse-quential delays	high risk	Early involvement of both MWS and experienced contractors Use certified vessels Detailed planning of installation procedures Interface management between designer, manufac-turer, and installation companies	very good	3	low risk	
Requirements not met and engineering errors may result in the use of unsuitable vessels, causing delays and potentially damage	medium risk	Involve personnel with offshore experience Full (engineering) checks and suitability surveys Experienced HSE engineers to be recruited, standby and guard vessels to be adequately equipped with rescue facilities (to be checked in combination with installation vessel facilities)	very good	2	low risk	
Inefficiency and lack of clarity may lead to unnecessary damage / injury	medium risk	Set-up clear emergency procedures and onshore organisation Organisation preferably done by developer to ensure an overall cover on all activities in the same manner (clarity)	very good	2	low risk	

9.7 Erection of tower, nacelle, and rotor

9.7.3 Transports to the port area assembling site

9.7.3	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	c)	Planning of transports of the wind turbine components Ex work to the offshore delivery point (port or shipyard)	Planning starts only upon completion, i.e. at a later time	medium
	c)	Planning of transports of the wind turbine components Ex work to the offshore delivery point (port or shipyard)	Inappropriate transport routes (dimensions, passageways, heights, load-bearing capacities)	high
	c)	Planning of transports of the wind turbine components Ex work to the offshore delivery point (port or shipyard)	Planning does not allow for availability of transport means and capacities of the forwarding company	high
	c)	Planning of transports of the wind turbine components Ex work to the offshore delivery point (port or shipyard)	Use of transport routes subject to time limitations (e.g. rivers)	high
	c)	Planning of transports of the wind turbine components Ex work to the offshore delivery point (port or shipyard)	No time buffer but transports delayed	high
	c)	Planning of transports of the wind turbine components Ex work to the offshore delivery point (port or shipyard)	Wrong selection of the transport unit; transport means of insufficient dimensions, e.g. because of wrong information on the object to be transported	medium

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.3
Implement the transport plan in the schedule for the entire project Transport planning and design planning in parallel Co-ordinate with manufacturers and logistics	adequate	4	medium risk	Scheduling of the transports should be part of the overall schedule	
Simulate the transport with real cargo data together with the forwarder and select experienced forwarder	very good	3	low risk	Particularly for riverboats, the allowed heights shall be observed.	
Early clear up availability and capacities of the forwarder, make booking, and stipulate this by contract	adequate	6	medium risk		
Schedule a time buffer Get hold of / verify alternative routes Verify empirical data Provide for alternative date(s)	adequate	6	medium risk	AdÜ	
Schedule time buffers Close co-ordination with customer / producer and the authorising body regarding the time schedule Provide for alternative date(s)	adequate	6	medium risk	On-time provision of wind turbine assemblies for erection	
Thoroughly analyse / plan the loading and transport sections Thoroughly plan loading and transport units Draw up stowing plans / method statements Specification of the cargo and transport means and co-ordination, validation, tracking by all partners involved Involve in design, project planning, etc. to provide for complete information	adequate	4	medium risk	You should aim at co-ordination and acceptance of all plans and schedules (technical plans, time schedules, logistic plans) as well as specifications with and by anyone involved and corresponding implementation	

9.7.3	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	c)	Planning of trans-ports of the wind turbine components Ex work to the offshore delivery point (port or shipyard)	Wrong selection of the transport unit; transport means of insufficient dimensions, e.g. because of wrong information on the object to be transported	high
	c)	Planning, trans-port, and storage of nacelle	Sealing incomplete	high
	c)	Planning, trans-port, and storage of nacelle	High number of loading and reloading procedures	high
	c)	Planning, trans-port, and storage of nacelle	No / wrong equipment for reloading (e.g. from the lorry onto the river boat or the like)	high
	c)	Planning, trans-port, and storage of nacelle	No / wrong equipment for reloading (e.g. from the lorry onto the river boat or the like)	high
	c)	Planning, trans-port, and storage of nacelle	Planning includes form faults, such as undersized transport means, wrong / old schedules, etc.	medium
	c)	Planning, trans-port, and storage of nacelle	Invalid documents on class / certification Certifier not commissioned on time	medium
	c)	Planning, trans-port, and storage of nacelle	Permits not asked for early	medium

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.3
Check, whether the transport unit, means, box, packaging suits the exposures to be expected such as: ▪ mechanical load, ▪ load by weather, ▪ ageing (very important), etc.	adequate	6	medium risk		
Check and/or plan sealing This should be designed for a use between -10 °C and 35 °C	adequate	6	medium risk		
Generally, minimise the number of loading and reloading procedures	adequate	6	medium risk	Loading and reloading procedures increase the risk of damage and, therefore, have to be minimised to those times that cannot be avoided	
Integrate the loading procedures in the planning Provide for information exchange on the occasion of regular project meetings Establish appropriate platforms to make available currently applicable specifications Allow for sufficient capacity reserves for weight Keep ready and plan handling aids and if required, e.g. special lift fixtures	adequate	6	medium risk		
Ask the hired forwarder / logistic company for proof that the adequate equipment will be available at the date Inspect the site and the transport means in advance	adequate	6	medium risk		
Independent second verification of transport plans (e.g. together with manufacturer)	adequate	4	medium risk	Verification of transport and logistics plans by a third person on the basis of the "four-eye principle"	
Thoroughly analyse / plan the loading and transport sections Thoroughly plan loading and transport units Prepare loading plans / method statements Early place the order and involve the certifier, in particular for an on-time verification of documents Certifier should go in parallel with planning The resources of the certifying companies should be taken into account, too	very good	2	low risk	Certifying processes can take a long time and be suddenly prolonged when corrections are required Therefore, the documents for any permit should be on hand early and the certifier should early be involved in planning	
Early place the order and involve the certifier, in particular for prompt verification of documents	very good	2	low risk	As already explained for the certifying processes, the procedure to issue a permit could take a long time and even much more time when corrections are required	

9.7.3	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	c)	Planning, trans-port, and storage of nacelle	No "emergency plans"	medium
	d)	Identification of appropriate port	Large transport distance between manufacturer and the port of shipment	medium
	d)	Identification of appropriate port	Not enough moorings	medium
	d)	Identification of appropriate port	Poor manoeuvrability during loading, e.g. with floating crane	medium
	d)	Identification of appropriate port	Insufficient storage capacities	medium
	d)	Identification of the requirements for the load on the handling/ storage/ pier areas	Port does not meet the requirements, e.g. port not suitable for heavy cargo	high
	d)	Identification of the requirements for the load on the handling/ storage/ pier areas	Damage to pier, storage area, and access ways	small

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.3
Draw up emergency plans together with the manufacturer and the operating party Alternatives, e.g. alternative transport routes Alternatives, e.g. lifting equipment by a second company	very good	2	low risk	For the case that any transport means, lifting equipment, route become unusable due to accidents / averages, etc., alternative plans should already be on hand, e.g. alternative routes / capacities of other forwarders should have been considered, etc.	
Thoroughly analyse / plan the requirements for the ports of loading/unloading, e.g. examination, simulation, and shakedown cruises to the port Check whether the ports meet the requirements - on-site inspection Request that any delay, occupancy, reserve is allowed for in the planning	adequate	4	medium risk		
Thoroughly analyse / plan the requirements for the ports of loading/unloading, e.g. examination, simulation, and shakedown cruises to the port Check whether the ports meet the requirements - on-site inspection Request that any delay, occupancy, reserve is allowed for in the planning	adequate	4	medium risk	Delays, unplanned occupancy of mooring due to delayed offshore installation should be allowed for in the planning	
Thoroughly analyse / plan the requirements for the ports of loading/unloading, e.g. examination, simulation, and shakedown cruises to the port Check whether the ports meet the requirements - on-site inspection Request that any delay, occupancy, reserve is allowed for in the planning	adequate	4	medium risk		
Thoroughly analyse / plan the requirements for the ports of loading/unloading, e.g. examination, simulation, and shakedown cruises to the port Check whether the ports meet the requirements - on-site inspection Request that any delay, occupancy, reserve is allowed for in the planning	adequate	4	medium risk	Delays, unplanned occupancy of storage area due to delayed offshore installation should be allowed for in the planning	
Thoroughly analyse / plan the requirements for the ports of loading/unloading Check whether ports meet the requirements - early on-site inspection together with the port operator in advance	adequate	6	medium risk		
Thoroughly analyse / plan the requirements for the ports of loading/unloading Check whether ports meet the requirements - early on-site inspection together with the port operator in advance	very good	1	low risk	Damage to pier etc. can occur in the meantime until loading will actually take place	

9.7.3	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	d)	Identification of the requirements for the load on the handling/ storage/ pier areas	Damage to pier, storage area, and access ways occur during loading	small
	d)	Planning of local transports and storage of the nacelles	Sealing incomplete	high
	d)	Planning of local transports and storage of the nacelles	High number of loading and reloading procedures	high
	d)	Planning of local transports and storage of the nacelles	No / wrong equipment for reloading (e.g. from the lorry onto the river boat or the like)	high
	d)	Planning of local transports and storage of the nacelles	No / wrong equipment for reloading (e.g. from the lorry onto the river boat or the like)	high
	d)	Planning of local transports and storage of the nacelles	Planning includes form faults, such as undersized transport means, wrong / old schedules, etc.	medium
	d)	Planning of local transports and storage of the nacelles	Invalid documents on class / certification Certifier not commissioned on time	medium
	d)	Planning of local transports and storage of the nacelles	Permits not asked for early	medium

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.3
Thoroughly analyse / plan the requirements for the ports of loading/unloading Check whether ports meet the requirements - early on-site inspection together with the port operator in advance and if required, make available alternatives and/or emergency plans	very good	1	low risk	For the case of unusable loading edges, alternatives or emergency plans should already be drawn up in advance	
Check and/or plan sealing This should be designed for a use between -10 °C and 35 °C	adequate	6	medium risk		
Generally, minimise the number of loading and reloading procedures	adequate	6	medium risk	Loading and reloading procedures increase the risk of damage and, therefore, have to be minimised to those times that cannot be avoided	
Integrate the loading procedures in the planning Provide for information exchange on the occasion of regular project meetings Establish appropriate platforms to make available currently applicable specifications Allow for sufficient capacity reserves for weight Keep ready and plan handling aids and if required, e.g. special lift fixtures	adequate	6	medium risk		
Ask the hired forwarder / logistic company for proof that the adequate equipment will be available at the date Inspect the site and the transport means in advance	adequate	6	medium risk		
Independent second verification of transport plans (e.g. together with manufacturer)	adequate	4	medium risk	Verification of transport and logistics plans by a third person on the basis of the "four-eye principle"	
Thoroughly analyse / plan the loading and transport sections Thoroughly plan loading and transport units Prepare loading plans / method statements Early place the order and involve the certifier, in particular for an on-time verification of documents Certifier should go in parallel with planning The resources of the certifying companies should be taken into account, too	very good	2	low risk	Certifying processes can take a long time and be suddenly prolonged when corrections are required Therefore, the documents for any permit should be on hand early and the certifier should early be involved in planning	
Early apply for any permit in consideration of potential deferments; plan time buffers in the overall project plan	very good	2	low risk	As already explained for the certifying processes, the procedure to issue a permit could take a long time and even much more time when corrections are required	

9.7.3	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	d)	Planning of local transports and storage of the nacelles	No "emergency plans"	medium
	c)	Reserving capaci-ties, personnel, and equipment for transports	No time buffer for availability, i.e. personnel and equipment are availa-ble at stated times, only.	very high
	c)	Reserving capaci-ties, personnel, and equipment for transports	No reserves for personnel and equipment capacities (number of persons large enough but no allowance for deviations) Equipment is sufficient, too, regarding its output capacity but insuffici-ent (unusable) for higher loads	very high
	c)	Reserving capaci-ties, personnel, and equipment for transports	No redundancies for any failure	very high
	c)	Reserving capaci-ties, personnel, and equipment for transports	Contractor's ability to supply, references, experiences not verified	medium
	i)	Supervision and approval of loading procedures and transports by certi-fier	Inadequate information policy	high
	i)	Supervision and approval of loading procedures and transports by certi-fier	No co-ordination with the other parties involved	high
	j)	Supervision and approval of loading procedures and transports by certi-fier	Inadequate information policy	high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.3
Draw up emergency plans together with the manufacturer and the operating party Alternatives, e.g. alternative transport routes Alternatives, e.g. lifting equipment by a second company	very good	2	low risk	For the case that any transport means, lifting equipment, route become unusable due to accidents and averages, etc., alternative plans should already be on hand, e.g. alternative routes / capacities of other forwarders should have been considered, etc.	
Schedule time buffers over the entire transport chain Track the production process closely as to deferments The overall project schedule should already include resources of personnel, equipment, etc. with sufficient time buffers	adequate	8	high risk	It is supposed that detailed project schedules (incl. exactly planned teams) are on hand already and that they include time buffers	
Plan quantity reserves for personnel and quality reserves for the transport equipment (dimensions, max. weights, etc.) Enough capacity reserves, personnel and equipment	adequate	8	high risk	It is supposed that detailed project schedules (incl. exactly planned teams) are on hand already Capacity reserves should also be planned in advance, e.g. they should be callable	
Identify strategic bottlenecks and, if required, provide for redundancies on call In this effect spare capacities (personnel, equipment) are to be developed in advance depending on their accessibility; also see the items above	adequate	8	high risk	Analyse and identify strategic bottlenecks and derive adequate redundancies	
Select contractors on the following criteria: ▪ capacity, ▪ experience gained in similar projects, ▪ good access to sub-contractors, ▪ creditworthiness assumed	very good	2	low risk	E.g. ship owners with experience in offshore wind energy and access to small shipping companies Tugboat crew with experience is very important to cope with the particularities of big wind turbine components	
Transparent information policy	adequate	6	medium risk		
Early co-ordinate with anyone involved, integrate the certifier in the project teams and relevant project meetings	adequate	6	medium risk	Involving the certifier, designation of certifier and substitute	
Transparent information policy	adequate	6	medium risk		

9.7.3	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	j)	Supervision and approval of loading procedures and transports by certi-fier	No co-ordination with the other parties involved	high
	i)	Overland transport footing structure Footing structure: This applies to any type of footing structures, such as monopiles, gravitati-on foundation, etc.	Ignoring / handling of process descriptions, such as method state-ments, transport specifications, instructions for actions, etc. by e.g. manufacturers / operating parties	high
	i)	Overland transport footing structure Footing structure: This applies to any type of footing structures, such as monopiles, gravitati-on foundation, etc.	Ignoring / handling of control mechanisms by e.g. manufacturers / operating parties	very high
	i)	Overland transport footing structure Footing structure: This applies to any type of footing structures, such as monopiles, gravitati-on foundation, etc.	Planning is not adapted to any changing requirement and consequently changing specifications regarding time, capacities, and technical requi-rements of the cargo	very high
	i)	Overland transport footing structure Footing structure: This applies to any type of footing structures, such as monopiles, gravitati-on foundation, etc.	Wrong and/or inadequate manoeuvring during loading	medium
	i)	Unloading footing structure	Intermediate storage unsuitable for weight, size, etc.	medium

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.3
Early co-ordinate with anyone involved, integrate the certifier in the project teams and relevant project meetings	adequate	6	medium risk	Involving the certifier, designation of certifier and substitute	
Strictly adhere to the procedure instructions Brief sub-contractors etc. Deviate only upon consultation of manufacturers and/or authorised persons	very good	3	low risk	The manufacturer's specifications are based on experience and any non-observance could entail e.g. damage to components Example: Wrong fixing of the lifting devices resulting in deformation of components	
Strictly adhere to the sequences of approval and release with the quality assurance department and certifiers etc.	very good	4	medium risk	The quality assurance department should supervise in principle all components in all process steps including commissioning ending up with the approval inspection / acceptance Any deviation is allowed only upon technical clarification and positive result by QA and with their consent	
Immediately adapt the plans upon getting to know of changes as well as inform in detail any involved partner in project meetings and on information platforms (servers etc.)	very good	4	medium risk	We assume that the overall project schedules are subject to continuous updates and changes are announced in the corresponding groups and committees	
Supervision by QA and if required by the certifier	very good	2	low risk		
Verify suitability within the scope of planning and immediately prior to execution	very good	2	low risk	Examples: ▪ Transport of rotor blades ▪ Intermediate stop on parking area ▪ Risk of grazing (AdÜ: schrammen KFZ-unfall oder ist starting gemeint?) ▪ Inappropriate storage of gear units and generators; beyond allowed angle of inclination	

9.7.3	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	i)	Unloading footing structure	Intermediate storage unsuitable for weight, size, etc.	medium
	i)	Unloading footing structure	Unloading equipment unsuitable	medium
	i)	Unloading footing structure	Unloading equipment unsuitable	high
	i)	Unloading footing structure	Wrong and/or inadequate manoeuvring during loading	medium
	i)	Overland transport ▪ Transition piece (transition piece depends on type of construction) ▪ Tower / tower segments ▪ Nacelles / drive train ▪ Rotor blades ▪ Hub	See footing structure	medium
	i)	Transport of tower segments	Deformation of the tower due to uneven load distribution during trans-port	very high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.3
See identification of appropriate ports: Thoroughly analyse / plan the requirements for the ports of loading/unloading and the storage capacities, e.g. examination, simulation, and shakedown cruises to the port Check whether the ports meet the requirements - on-site inspection Request that any delay, occupancy, reserve is allowed for in the planning	adequate	4	medium risk	See identification of appropriate ports: ▪ Delays ▪ Unplanned occupancy of storage area due to delayed offshore installation should be allowed for in the planning	
Verify suitability within the scope of planning and immediately prior to execution	very good	2	low risk	Basically, any equipment / auxiliary means used should be exclusively designed for this purpose Provisional solutions are inacceptable and only allowed upon prior consent of the manufacturer	
Integrate the loading procedures in the planning Provide for information exchange on the occasion of regular project meetings Establish appropriate platforms to make available currently applicable specifications Allow for sufficient capacity reserves for weight Keep ready and plan handling aids and if required, e.g. special lift fixtures	adequate	6	medium risk		
Supervision by QA and if required by the certifier	very good	2	low risk		
	adequate	4	medium risk	The aforementioned risks and protection measures for footing structures also apply to the overland transport of other main components of the wind turbines, such as the transition piece (if type of construction includes such), tower / tower segments, nacelles / drive train, rotor blades, and hub	
Pay attention to even load distribution during transportation	adequate	8	high risk		

9.7.3	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	i)	Unloading: ▪ Transition piece (transition piece depends on type of construction) ▪ Tower / tower segments ▪ Nacelles / drive train ▪ Rotor blades ▪ Hub	See footing structure	medium
	i)	Loading procedures - blades	Rotating blades when wind is springing up	high
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub	Incomplete planning of sequences of erection Single steps missing	high
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub		high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.3
	adequate	4	medium risk	The aforementioned risks and protection measures for footing structures also apply to the overland transport of other main components of the wind turbines, such as the transition piece (if type of construction includes such), tower / tower segments, nacelles / drive train, rotor blades, and hub	
Always use two cranes for loading	adequate	6	medium risk		
Use experience by involving experienced colleagues The majority of the project team - e.g. 80 % - should be skilled colleagues with experience in erection	adequate	6	medium risk	Experience is imparted within the team from an experienced person to a person with less experience	
Use of: ▪ simulation ▪ trying out ▪ feasibility studies ▪ FMEAs together by the departments for design, assembling, logistics, and process design / work scheduling Regular project meetings	adequate	6	medium risk	Experience gained from previous erections of prototypes, simulations is used	

9.7.3	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub		high
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub		high
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub	Planning rigid regarding project changes and delays	medium

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.3
Documentation of the results from the following: ▪ experiences gained in the assembly of onshore prototypes ▪ experiences of the assembly personnel ▪ simulations ▪ trying out	adequate	6	medium risk	Availability of results and information to anyone involved in the project by regular documentation	
Make the QA and certifier verify this	adequate	6	medium risk	Continuous supervision, testing, and approval inspections by QA, even in the sense of duplication checks	
Allow for sufficient resources	adequate	4	medium risk	Planning of sufficient resource capacities in the teams, for the equipment, etc.	

9.7.3	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub		medium
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub	Planning per item refers to only one supplier / service provider	medium
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub	Current changes of standards and regulations or the legislation Planning still as things were before, not up-to-date	small

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.3
Allow for reserves in the overall project plan already	adequate	4	medium risk	Allow for reserves in time, personnel, and finances and draw up emergency plans	
Provide for emergency plan Early develop an alternative to change the service providers	adequate	4	medium risk	E.g. in case of insolvency of a service provider of erection work, a competent alternative should have been identified before	
Regularly check applicable standards, regulations, laws	adequate	2	low risk	Project team or one designated member of this permanently reads up on standards and regulations	

9.7.3	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub	Planned sequences of erection not possible / practicable	high
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub		high
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub		high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.3
Use of: ▪ simulation ▪ trying out ▪ feasibility studies ▪ FMEAs together by the departments for design, assembling, logistics, and process design / work scheduling Regular project meetings	adequate	6	medium risk		
Use experience by involving experienced colleagues The majority of the project team - e.g. 80 % - should be skilled colleagues with experience in erection Use experiences by verification of sequencs and/or the aforementioned simulation in co-operation with experienced colleagues	adequate	6	medium risk	Experience is imparted within the team from an experienced person to a person with less experience	
Use following experiences: ▪ Experiences gained in the assembly of onshore prototypes ▪ Experiences of the assembly personnel	adequate	6	medium risk	Experience gained from previous erections of prototypes, simulations is used	

9.7.3	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub		high
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub	Times Time required for a sequence of erection underestimated	high
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub		high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.3
Documentation of the results from the following: ▪ Experiences gained in the assembly of onshore prototypes ▪ Experiences of the assembly personnel ▪ Simulations ▪ trying out	adequate	6	medium risk	Availability of results and information to anyone involved in the project by regular documentation	
Take the times Simulate / try out Feasibility studies	adequate	6	medium risk		
Use following experiences: ▪ Experiences gained in the assembly of onshore prototypes ▪ Experiences of the assembly personnel	adequate	6	medium risk	Experience gained from previous erections of prototypes, simulations is used	

9.7.3	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub		high
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub	Effects of the weather insufficiently considered or not considered at all	medium
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub		medium

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.3
Training of erection teams; in the manufacturer's work, too	adequate	6	medium risk		
Allow for enough time buffer, allow for the effects of weather and season in planning	poor	6	medium risk	It is supposed that detailed project schedules (incl. exactly planned teams) are on hand already Where possible, scheduling should provide for time buffers	
Allow for reserves (personnel and equipment), perhaps reserve them to compensate for adverse weather during erection with close supervision and check by QA	adequate	4	medium risk	Planning of additional erection capacities; e.g. in the form of third skilled and experienced co-operation partners, that have reserved the capacities (personnel and equipment)	

9.7.3	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub	Resources: Quantity and time planned for resources of personnel / equipment are insufficient	high
	d)	Planning, work, assembly work, fitting work in the port area / at the shipyard, etc. as to the main compo-nents: ▪ Footing structure ▪ Transition piece (if any) ▪ Tower / tower segments ▪ Nacelle / drive train ▪ Rotor blades ▪ Hub		high

Legend
a) Execution planning of soil investigation for locations of offshore wind turbines
b) Soil investigation for locations of offshore wind turbines
c) Execution planning of the inland transport (overland and rivers) from the factory to the offshore port
d) Execution planning of the storage in the offshore port and the onshore assembly there
e) Execution planning of offshore transports
f) Execution planning of offshore erection
g) Execution planning of residual assembly work offshore
e) Execution planning of the commissioning and the test run until getting the PAC
i) Inland transport (overland and rivers) from the factory to the offshore port
j) Storage in the offshore port and the onshore assembly there
k) Offshore transports
l) Offshore erection
m) Residual assembly work offshore
n) Commissioning and test run until getting the PAC

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.3
Make experienced personnel verify this as mentioned above for the construction engineering: ▪ Experiences gained in the assembly of onshore prototypes ▪ Experiences of the assembly personnel etc.	adequate	6	medium risk		
Make third external experts etc. verify the planning - as mentioned above	adequate	6	medium risk		

9.7 Erection of tower, nacelle, and rotor

9.7.4 Work, assembly work, fitting work in the port area / at the shipyard, preparations for offshore erection

9.7.4	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	j)	Inspection of ram piles after transport as one step to prepa-re offshore erection	Damage due to improper transport, loading, and storage	high
	j)	Inspection of ram piles after transport as one step to prepa-re offshore erection		high
	j)	Inspection of ram piles after transport as one step to prepa-re offshore erection		high
	j)	Inspection of ram piles after transport as one step to prepa-re offshore erection	Single components not operational (transport damage)	small
	j)	Erection of footing structure and transi-tion piece	Improper transport and loading	very high
	j)			very high
	j)		Single components incl. corrosion protection not operational (transport damage)	medium
	j)	Tests Certifications Footing structure	Compliance with structural requirements and the specifications laid down (types of material, sizes of walls, etc.)	medium
	j)		Pressure of time Compliance with set dates	high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.4
Use a check sheet for transport and loading; make MWS verify this	poor	9	high risk	(if the type of construction includes ram piles)	
Make the stress analyst verify the method statements and execute approval inspection of the loaded piles prior to any onshore transport	adequate	6	medium risk	Correct static and constructional design of the transport is decisive	
Enough own qualified and experienced personnel incl. the MWS Supervise loading	poor	9	high risk	Also see project stage 2, highly assessed for experiences One decisive factor is the work with experienced personnel	
Quality assurance: ▪ Visual inspection	adequate	2	low risk	Also see project stage 2, inspections prior to any further use of poor components - here the ram piles	
Use a check sheet for transport and loading	adequate	8	high risk	Also see project stage 2	
Enough own qualified and experienced personnel incl. the MWS Supervise loading	very good	4	medium risk	Also see project stage 2, highly assessed for experiences One decisive factor is the work with experienced personnel	
Quality assurance ▪ Visual inspection	adequate	4	medium risk	Also see project stage 2 Inspections incl. passive corrosion protection and if there is active corrosion protection, check of this, too	
Quality assurance: ▪ Visual inspection ▪ Inspection of joints / weld seams ▪ Check whether compliance with specifications	adequate	4	medium risk	The inspections / checks mentioned here are meant to be duplication checks Generally, only approved and accepted components should leave the factories The main inspections should be made in the factory	
Time and mounting schedule Allow for time buffers	adequate	6	medium risk	As mentioned above: It is supposed that detailed project schedules (incl. exactly planned teams) are on hand already Where possible, scheduling should provide for time buffers	

9.7.4	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	j)		Certifier does not detect deficiencies	high
	j)			high
	j)	Erection of footing structure if gravitati-on foundations	Compliance with structural requirements and the specifications laid down (types of material, sizes of walls, etc.)	high
	j)	Any onshore prepa-ration, assembly, installation, test, check, etc.	During mounting, installation, etc. heat intensive tasks (welding, abrasive cutting, etc.) or e.g. the test run of electric devices in connec-tion with fire load can cause fire and explosions	medium
	j)	Preparation of tower or assembly of tower segments	Single components not operational (transport damage)	medium
	j)	Preparation nacelle / drive train	Single components not operational (transport damage), perhaps the last onshore function tests of a single component not carried out	medium

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.4
Select and book only those certifiers who can prove their experience	adequate	6	medium risk	As only a limited number of certifiers is available in the market, book them early	
Involve the manufacturer's quality assurance in parallel to and independent of the certifier	adequate	6	medium risk	Complementary checks by QA to improve detection of deficiencies	
Quality assurance: ▪ Approval inspection of the reinforcement prior to pouring of concrete ▪ Check of the concrete quality ▪ Sampling of concrete ▪ Check whether compliance with specifications etc.	adequate	6	medium risk	Example, concrete quality certificates, approval inspections of reinforcement by inspecting structural engineer / engineering office	
Prepare risk analyses for all commissioning sequences Take steps against risks (such as permit procedure for heat intensive tasks, fire guards after heat intensive tasks, provision of corresponding fire detectors, provision of fire extinguishing agent, personnel training and practice, emergency plans, etc.)	adequate	4	medium risk	Fire protection is to be integrated in all sequences and the safety officers are to be involved in all sequences, e.g. using risk analyses and by participation in project meetings, on-site inspections, etc.	
Quality assurance: ▪ Execution of corresponding checks	adequate	4	medium risk	As mentioned above: The checks mentioned here are meant to be duplication checks Generally, only approved and accepted components should leave the factories The main inspections should be made in the factory	
Quality assurance: ▪ Check list whether the function test prior to shipment took place, all o.k.	adequate	4	medium risk	As mentioned above: The checks mentioned here are meant to be duplication checks Generally, only approved and accepted components should leave the factories The main inspections should be made in the factory	

9.7.4	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	j)		Insufficient sealing of openings against effects by weather and seastate	medium
	j)	Assembly of rotor blades, hub, or star (one variant)	Improper lifting, transport, and loading	very high

Legend
a) Execution planning of soil investigation for locations of offshore wind turbines
b) Soil investigation for locations of offshore wind turbines
c) Execution planning of the inland transport (overland and rivers) from the factory to the offshore port
d) Execution planning of the storage in the offshore port and the onshore assembly there
e) Execution planning of offshore transports
f) Execution planning of offshore erection
g) Execution planning of residual assembly work offshore
e) Execution planning of the commissioning and the test run until getting the PAC
i) Inland transport (overland and rivers) from the factory to the offshore port
j) Storage in the offshore port and the onshore assembly there
k) Offshore transports
l) Offshore erection
m) Residual assembly work offshore
n) Commissioning and test run until getting the PAC

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.4
Quality assurance: ▪ Supervision of works ▪ Checks, e.g. visual inspections and ▪ check lists for all critical seals	adequate	4	medium risk	Adequate weather protection (against rain, frost, air humidity, lightning, etc.) to be ensured onshore during preassembly, as well, especially when carried out on an area that is not housed As e.g. seals could have to be removed for access, here attention shall be paid to safe locking	
Compliance with assembly procedures: ▪ Check sheets ▪ Cover blade bearings ▪ Protect stud bolts	adequate	8	high risk	Compliance with procedure instructions and sequences to ensure proper and perfect assembly	

9.7 Erection of tower, nacelle, and rotor

9.7.5 Loading for sea transport

9.7.5	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Offshore transports	Loading for sea transport	Loading of tower	Load-out	Grillage and/or sea-fastening incorrect Soil risk on locations where jacks are used Accessibility of the structures for loading Accessibility of the quayside Availability of required onshore equipment such as cranes Weather conditions (wind) Weight control MWS approval
	Offshore transports	Loading for sea transport	Loading of nacelle	Load-out	Grillage and/or sea-fastening incorrect Soil risk on locations where jacks are used Accessibility of the structures for loading Accessibility of the quayside Availability of required onshore equipment such as cranes Weather conditions (wind) Weight control MWS approval
	Offshore transports	Loading for sea transport	Loading of rotor	Load-out	Grillage and/or sea-fastening incorrect Soil risk on locations where jacks are used Accessibility of the structures for loading Accessibility of the quayside Availability of required onshore equipment such as cranes Weather conditions (wind) Weight control MWS approval

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status
Damage to components of the wind mill, the vessel, or the quayside	high risk	Feasibility studies at an early stage Clear procedures Interface management between yard, MWS, and contractor Use of certified vessels: Experienced construction manager and installation engineers to be recruited early to set-up adequate procedures and establish engineering standards for weight control and design	very good	3	low risk
Damage to components of the wind mill, the vessel, or the quayside	high risk	Feasibility studies at an early stage Clear procedures Interface management between yard, MWS, and contractor Use of certified vessels: Experienced construction manager and installation engineers to be recruited early to set-up adequate procedures and establish engineering standards for weight control and design	very good	3	low risk
Damage to components of the wind mill, the vessel, or the quayside	high risk	Feasibility studies at an early stage Clear procedures Interface management between yard, MWS, and contractor Use of certified vessels: Experienced construction manager and installation engineers to be recruited early to set-up adequate procedures and establish engineering standards for weight control and design	very good	3	low risk

9.7.5	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Offshore transports	Loading for sea transport	Loading of systems and equipment for turbine	Load-out	Grillage and/or sea-fastening incorrect Soil risk on locations where jacks are used Accessibility of the structures for loading Accessibility of the quayside Availability of required onshore equipment such as cranes Weather conditions (wind) Weight control MWS approval

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.7.5
Damage to components of the wind mill, the vessel, or the quayside	high risk	Feasibility studies at an early stage Clear procedures Interface management between yard, MWS, and contractor Use of certified vessels: Experienced construction manager and installation engineers to be recruited early to set-up adequate procedures and establish engineering standards for weight control and design	very good	3	low risk	

9.7 Erection of tower, nacelle, and rotor

9.7.6 Sea transport to the wind farm

9.7.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Execution planning of offshore transports	Sea transport to offshore wind farm	Route planning incl. alternative ports		Planning	Route / port blocked Interface between vessel inshore or offshore
	Execution planning of offshore transports	Sea transport to offshore wind farm	Clear up allowed sea state and weather conditions with MWS / certifier			Only an issue if work is performed on a day-rate basis Lump sum contracts should include weather downtime
	Execution planning of offshore transports	Sea transport to offshore wind farm	Clear up whether MWS will be available during transport			Not applicable during transportation other than previous box
	e)	Sea transport to offshore wind farm	Drawing up emergency plans / designation of responsible persons			Safety culture on board of the vessels, availability of safety equipments and means (helicopter platform for emergencies)
	Offshore transports	Sea transport to offshore wind farm	Sea transport of tower		Sailing	Grillage and/or sea-fastening incorrect Exceeding movement tolerances of the structures (sea state / conditions)
	Offshore transports	Sea transport to offshore wind farm	Sea transport of nacelle		Sailing	Grillage and/or sea-fastening incorrect Exceeding movement tolerances of the structures (sea state / conditions)
	Offshore transports	Sea transport to offshore wind farm	Sea transport of rotor		Sailing	Grillage and/or sea-fastening incorrect Exceeding movement tolerances of the structures (sea state / conditions)
	Offshore transports	Sea transport to offshore wind farm	Sea transport of systems and equipment for turbine		Sailing	Grillage and/or sea-fastening incorrect Exceeding movement tolerances of the structures (sea state / conditions)

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.7.6
Requirement for alter-native route Delay Consequential standby charges of vessels	medium risk	See actions during planning stage If this is done properly, item 1 should not appear Ad item 2: Set-up interface communication between the different onshore and offshore contractors and avoid just in time planning	very good	2	low risk	
Delay Damage to the compo-nents Payment of additional day-rates	high risk	Contracts to include weather risk clarification, preferably as part of lump sum of the contractor Contracts need to define required weather and sea state Ensure a sufficient budget estimate on weather delays Require fabricators to comply with reasonable limitations considering the anticipated sea state at the required location	adequate	6	medium risk	
Delays and consequen-tial costs	medium risk	Early involvement of MWS on transportation metho-dology	very good	2	low risk	
Missing the appropri-ate safety culture and required equipment and facilities hugely incre-ases the risk of damage or injuries	medium risk	Make sure the contractor has a good and proven safety system, procedures, and culture	very good	2	low risk	
Damage to / loss of property Reconsideration of requirements by MWS, CA, or BSH	medium risk	Use certified vessels Use actions identified at the planning stage Endeavour to enforce an increase of acceptable movement tolerances of the components	very good	2	low risk	
Damage to / loss of property Reconsideration of requirements by MWS, CA, or BSH	medium risk	Use certified vessels Use actions identified at the planning stage Endeavour to enforce an increase of acceptable movement tolerances of the components	very good			
Damage to / loss of property Reconsideration of requirements by MWS, CA, or BSH	medium risk	Use certified vessels Use actions identified at the planning stage Endeavour to enforce an increase of acceptable movement tolerances of the components	very good		low risk	
Damage to / loss of property Reconsideration of requirements by MWS, CA, or BSH	medium risk	Use certified vessels Use actions identified at the planning stage Endeavour to enforce an increase of acceptable movement tolerances of the components	very good		low risk	

9.7.6	Process steps	Short description of operation	Requirements for the operation	Requirements in detail	Risks	Events
	Offshore transports	Sea transport to offshore wind farm	Sea transport of rotor	Wave damage to blade tips	Sailing	Rotor star mounted to low on deck of transport barge
	Offshore transports	Sea transport to offshore wind farm	Sea transport of tower	Damage to towers	Sailing	Sea fastening design, frames inadequate or barge deck not strong enough to cope with uplift, shear, or overturning forces causing frame moving and flexing introducing stress into tower flange

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.7.6
Damage to blade tips due to wave impact	medium risk	Full engineering checks and suitability surveys Naval architect studies for vessel pitch and roll characteristics	very good	2	low risk	
Tower flange damaged preventing installati-on and erection from proceeding	medium risk	Full engineering checks and suitability surveys	very good	2	low risk	

9.7 Erection of tower, nacelle, and rotor

9.7.7 Erection of tower, nacelle, and rotor

9.7.7	Process steps	Short description of operation	Requirements for the operation	Risks	Events
	Offshore erection	Erection of tower, nacelle, and rotor	Assembly of tower	Weather / environment	Weather criteria, water depth (for jacking) Accessibility, soil conditions (for jacking) Clearances on the vessel Alignment of tower sections
	Offshore erection	Erection of tower, nacelle, and rotor	Assembly of nacelle	Weather / environment	Weather criteria, water depth (for jacking) Accessibility, soil conditions (for jacking) Clearances on the vessel Alignment of tower sections
	Offshore erection	Erection of tower, nacelle, and rotor	Assembly of rotor	Weather / environment	Weather criteria, water depth (for jacking) Accessibility, soil conditions (for jacking) Clearances on the vessel Alignment of tower sections
	Offshore erection	Erection of tower, nacelle, and rotor	1 piece installation	Weather / environment	Weather criteria, accessibility Clearances on the vessel, alignment with the TP Pitch and roll forces exceed bearing design capacity Dynamic positioning
	Offshore erection	Erection of tower, nacelle, and rotor	Winter installation	Ice build-up	Ice build-up on jacking system or WTG components
	Offshore erection	Erection of tower, nacelle, and rotor	Installation work	Jack-up vessel	Jacking operations Soil conditions
	Offshore erection	Erection of tower, nacelle, and rotor	General installation	Floating vessel	Shock load
	Offshore erection	Erection of tower, nacelle, and rotor	General installation	Dropped objects	Dropped objects injure worker on foundation
	Offshore erection	Erection of tower, nacelle, and rotor	General installation	Transfer of crew	Poor boarding Landing facilities
	-	Erection of tower, nacelle, and rotor	Pulling of cables into the wind turbine	CHECK INTERFACE WITH CABLE SUBGROUP	CHECK INTERFACE WITH CABLE SUBGROUP

Consequences	Risk assess-ment	Protection measure	Assessment of protection measures	Relevance	Status	9.7.7
Working towards the limitations of the vessels Vessel cannot perform the work - delay Damage to the compo-nents	medium risk	Ensure spare capacity on all required features of the vessel Sound engineering checks at early stage Better / more intensive soil surveys	poor	6	medium risk	
Working towards the limitations of the vessels Vessel cannot perform the work - delay Damage to the compo-nents	medium risk	Ensure spare capacity on all required features of the vessel Sound engineering checks at early stage Better / more intensive soil surveys			medium risk	
Working towards the limitations of the vessels Vessel cannot perform the work - delay Damage to the compo-nents	medium risk	Ensure spare capacity on all required features of the vessel Sound engineering checks at early stage Better / more intensive soil surveys			medium risk	
- damage to compon-ents / bearings due to exceeding of movement criteria	medium risk	Sound engineering checks at early stage Change design of WTG to allow higher movement criteria	poor	6	medium risk	
Delay to the operation	low risk	Use a TJU with a non rack and pinion jacking system Have steam lances and piping in place to quickly clear off ice build up	very good	1	low risk	
Jack-up leg punched through Soil disturbance due to jacking	very high risk	Better / more intensive soil surveys	adequate	8	high risk	
Shock load during jacking Shock load during installation (floating vessel)	high risk	Use of heave compensation (floating vessel) Sound engineering checks	adequate	6	medium risk	
Injury	medium risk	Ensure good safety culture/system is in place	very good	2	low risk	
Injury	medium risk	Improve gangways and use of up-to-date marine vessels	very good	2	low risk	
CHECK INTER-FACE WITH CABLE SUBGROUP		CHECK INTERFACE WITH CABLE SUBGROUP				

9.7 Erection of tower, nacelle, and rotor

9.7.8 Commissioning

9.7.8	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	n)	Any offshore assembly, installation, test, inspection, etc. during commissioning	During mounting, installation, etc. heat intensive tasks (welding, abrasive cutting, etc.) or e.g. the test run of electric devices in connection with fire load can cause fire and explosions Increased fire loads, such as stored fuel quantities to run emergency generators, cannot be excluded and present an increased danger compared to standard operation	very high
	n)	Any offshore assembly, installation, test, inspection, etc. during commissioning	During mounting, installation, etc. heat intensive tasks (welding, abrasive cutting, etc.) or e.g. the test run of electric devices in connection with fire load can cause fire and explosions Increased fire loads, such as stored fuel quantities to run emergency generators, cannot be excluded and present an increased danger compared to standard operation	medium
	n)	Tests and inspection of fire protection equipment	Test not successful Fire protection equipment to be repaired	medium
	n)	Tests and inspection of fire protection equipment	During the overall commissioning of the wind turbine and the mounting, installation, etc. heat intensive tasks (welding, abrasive cutting, etc.) or e.g. the test run of electric devices in connection with fire load can cause fire and explosions	very high
	n)	Commissioning work, in general	Faulty commissioning, programming, tests, etc.	high
	n)	Commissioning work, in general	Missing tools, material, etc.	high
	n)	Overall commissioning of the wind turbine together with the wind farm	Control room not yet finished / ready for test Control technology faulty	medium

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.8
Priority commissioning of fire detection and fire alarm systems, fire extinguishing system, etc. for the turbine	very good	4	medium risk	This aims at adequate fire protection especially for the commissioning to protect persons and property Among other things especially for the case that no-one is on-site during commissioning and an increased fire load could be present and e.g. the effects of any assembly work (smouldering fires due to heat intensive tasks) is not detected early	
Use thermographic cameras during commissioning of electrical components to detect faults in planning or assembly	very good	2	low risk	The use of thermographic cameras during the commissioning of electrical components to detect weak points has been well tried	
Enough onshore tests Adequate securing of cargo Experienced and trained installation personnel and suitable installation equipment Supervising and testing QA during manufacture Assembly and commissioning	very good	2	low risk		
Commissioning of the fire protection systems for the wind turbine prior to the overall commissioning of it	very good	4	medium risk		
Priority commissioning of the machine guards and the emergency functions of the turbine	adequate	6	medium risk	In order to exclude any damage by switching errors, incorrect programming or operating, the machine guards should be set to work immediately upon erection The same applies to the emergency functions of the turbine, e.g. alignment in the wind of the nacelle during a storm	
Prepare exactly Simulate the sequences Perform tests and trainings on prototypes / material reserves Plan the tools in advance	adequate	6	medium risk		
Time schedule to be synchronised with the overall project schedule Early co-ordinate the work to be done	adequate	4	medium risk	Information to group 1 ▪ Sub-station	

9.7.8	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	n)	Overall commissi-oning of the wind turbine together with the wind farm	External mains connection not yet in working order	high
	n)	Overall commissi-oning of the wind turbine together with the wind farm	External mains connection not yet in working order	high
	n)	Overall commissi-oning of the wind turbine together with the wind farm	Documentation not yet on hand (e.g. certificate BGV A3, circuit diagrams, maintenance instructions, etc.)	medium
	n)	Overall commissi-oning of the wind turbine together with the wind farm	Start-up personnel not sufficiently qualified	high
	n)	Overall commissi-oning of the wind turbine together with the wind farm	Weather and sea conditions not optimum	medium
	n)	Supervision of start-up by the certifiers	Missing resources at the certifier	high
	n)	Supervision of start-up by the certifiers	Qualification of certifier and/or the persons involved	medium
	n)	Supervision of start-up by the certifiers	Delay of commissioning due to insufficient co-ordination by certifiers and customer	medium
	n)	Tests of single components	Parts of components, incl. the corrosion protection, are faulty etc.	medium
	n)	Tests of single components	Inappropriate test carried out	small

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.8
Time schedule to be synchronised with the overall project schedule	poor	9	high risk	Information to group 1 ▪ Sub-station	
Early plan emergency power (e.g. emergency generators etc.)	adequate	6	medium risk	The project schedule should allow for the power supply required to maintain circuit integrity, particularly for the emergency functions of the wind turbine	
Early schedule documentation and corresponding documents Make the start-up personnel and the operating personnel as well as the QA check the documentation to find errors If required, subject submittal of documents to penalties	adequate	4	medium risk		
Early hire personnel Train and instruct the personnel Proof of the employee's qualification when working for external service providers to be condition for deployment	adequate	6	medium risk		
Plan the weather slot for start-up according to the meteorological data and taking experiences into account Allow for sufficient buffer for bad weather / select alternative weather slot	adequate	4	medium risk	Normally, the overall project schedules are geared in the long run to the appropriate weather slots in the corresponding year	
Early synchronise resources and co-ordinate commissioning with the certifier to get hold of resources	adequate	6	medium risk	As only a limited number of certifiers is available in the market, book them early	
Early verify qualification (personal records etc.) of the test engineers involved Where required, turn down the project manager	adequate	4	medium risk		
Early co-ordinate the work to be done and the documents to be examined	adequate	4	medium risk		
Enough onshore tests Adequate securing of cargo Experienced installation personnel and suitable installation equipment Production supervision Permanent quality assessment	very good	2	low risk		
Clear specifications of test and testing criteria, to be laid down by the manufacturers Make QA and the certifier carry out the tests	adequate	2	low risk		

9.7.8	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	n)	Tests and inspection of machine safety devices	Damage to machine safety device due to test	small
	n)	Tests and inspection of machine safety devices	Faulty machine safety device	small
	n)	Tests and inspec-tion of connections and joints to the sub-station	Faulty connections (design)	small
	n)	Tests and inspec-tion of connections and joints to the sub-station	Injury to testing personnel, e.g. by overvoltage	high
	n)	Tests and inspection of the overall wind turbine (assumption: single wind turbine)	Defective components	small
	n)	Tests and inspection of the overall wind turbine (assumption: single wind turbine)	Injury to testing personnel	high
	n)	Tests and inspection of the overall wind turbine (assumption: single wind turbine)	Inappropriate test to sufficiently test the overall wind turbine	small
	n)	Function tests, emergency functions (assumption: emergency power system on OSS AdÜ: operations support system?)	Defective components	small

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.8
Test procedures well-tried and exactly defined Make experienced personnel carry out the tests Use appropriate testing equipment Correct execution of the tests (check lists)	adequate	2	low risk	The machine safety devices and the devices to maintain emergency functions are essential for functioning and to avert damage to a wind turbine	
Enough onshore tests, adequate securing of cargo Experienced installation personnel and suitable installation equipment Production supervision In-process quality assessment	very good	1	low risk		
Enough onshore tests, adequate securing of cargo Experienced installation personnel and suitable installation equipment Production supervision, permanent quality assessment	very good	1	low risk		
Sufficient protection measures within the scope of work safety Sufficiently experienced and qualified personnel	very good	3	low risk		
Enough onshore tests Adequate securing of cargo Experienced installation personnel and suitable installation equipment Permanent quality assessment	very good	1	low risk		
Sufficient protection measures within the scope of work safety Sufficiently experienced and qualified personnel	very good	3	low risk		
Clear specifications of test and testing criteria, to be laid down by the manufacturers Make QA and the certifier carry out the tests	adequate	2	low risk	See footing structure	
Enough onshore tests Adequate securing of cargo Experienced installation personnel and suitable installation equipment Permanent quality assessment	very good	1	low risk		

9.7.8	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	n)	Function tests, emergency functions (assumption: emergency power system on OSS AdÜ: operations support system?)	Injury to testing personnel	high
	n)	Function tests, emergency functions (assumption: emergency power system on OSS AdÜ: operations support system?)	Inappropriate test to sufficiently test the overall wind turbine	small
	n)	Machine protection not yet operational during commissio-ning of wind turbine	Machines damaged	medium
	n)	Function test of the entire system during operation	Defective components	small
	n)	Function test of the entire system during operation	Injury to testing personnel	high
	n)	Function test of the entire system during operation	Inappropriate test to sufficiently test the overall wind turbine	small
	n)	Function test of the entire system during operation	Delay caused by ambient conditions (bad weather, poor winds, etc.)	high
	n)	Function test of the entire system during operation	Damage to electrical components (transformer, generator, switch-gears, etc.) due to overvoltage during test operation (e.g. by invalid switching on USP AdÜ?)	high
	n)	Acceptance of wind turbine by operating party and certifier	Missing resources at the certifier / contractor (operating party)	high
	n)	Mains connection of sub-station	Damage to switchgear when connecting the first time	medium

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.8
Sufficient protection measures within the scope of work safety Sufficiently experienced and qualified personnel	very good	3	low risk		
Clear specifications of test and testing criteria, to be laid down by the manufacturers Make QA and the certifier carry out the tests	adequate	2	low risk		
Early commissioning, in any case prior to the commissioning of the wind turbine as mentioned in the beginning of project stage 2	adequate	4	medium risk		
Enough onshore tests Adequate securing of cargo, experienced installation personnel, and suitable installation equipment Production supervision, permanent quality assessment	very good	1	low risk		
Sufficient protection measures within the scope of work safety Sufficiently experienced and qualified personnel	very good	3	low risk		
Clear specifications of test and testing criteria, to be laid down by the manufacturers Make QA and the certifier carry out the tests	adequate	2	low risk		
Wait for appropriate weather slot and flexibly plan the resources (ships and persons) to ensure that the overall test passes off smoothly	adequate	6	medium risk		
Properly design, dimension, and establish the entire integrated electrical system Calculate and simulate potential switching procedures Co-ordinate planning with grid operator and comply with connection conditions	adequate		low risk		
Early synchronise resources and co-ordinate commissioning with the certifier to get hold of resources	adequate	6	medium risk		
Sufficiently experienced and qualified installation personnel Enough onshore tests	adequate	4	medium risk	Interface to sub-station	

9.7.8	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	n)	Overall commissio-ning of the wind farm as one component (also see sub-station)	Delay caused by ambient conditions (bad weather, poor winds, etc.)	high
	n)	Any offshore assem-bly, installation, test, inspection, etc. during commissio-ning	During mounting, installation, etc. heat intensive tasks (welding, abrasive cutting, etc.) or e.g. the test run of electric devices in connec-tion with fire load can cause fire and explosions Increased fire loads, such as stored fuel quantities to run emergen-cy generators, cannot be excluded and present an increased danger compared to standard operation	very high
	n)	Any offshore assem-bly, installation, test, inspection, etc. during commissio-ning	During mounting, installation, etc. heat intensive tasks (welding, abrasive cutting, etc.) or e.g. the test run of electric devices in connec-tion with fire load can cause fire and explosions Increased fire loads, such as stored fuel quantities to run emergen-cy generators, cannot be excluded and present an increased danger compared to standard operation	very high
	n)	Any offshore assem-bly, installation, test, inspection, etc. during commissio-ning	During mounting, installation, etc. heat intensive tasks (welding, abrasive cutting, etc.) or e.g. the test run of electric devices in connec-tion with fire load can cause fire and explosions Increased fire loads, such as stored fuel quantities to run emergen-cy generators, cannot be excluded and present an increased danger compared to standard operation	medium
	n)	Tests and inspection of fire protection equipment	Test not successful Fire protection equipment to be repaired	medium
	n)	Tests and inspection of fire protection equipment	During the overall commissioning of the wind turbine and the mounting, installation, etc. heat intensive tasks (welding, abrasive cutting, etc.) or e.g. the test run of electric devices in connection with fire load can cause fire and explosions	very high
	n)	Commissioning in general	Faulty commissioning, programming, tests, etc.	high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.8
Wait for appropriate weather slot and flexibly plan the resources (ships and persons) to ensure that the overall test passes off smoothly	adequate	6	medium risk	Interfaces with wind turbine, cable, and sub-station to be cleared up, commissioning from control room, offshore or onshore	
Prepare risk analyses for all commissioning sequences Take steps against risks (such as permit procedure for heat intensive tasks, fire guards after heat intensive tasks, provision of corresponding fire detectors, provision of fire extinguishing agent, personnel training and practice, emergency plans, etc.)	adequate	8	high risk	Fire protection is to be integrated in all sequences and the safety officers are to be involved in all sequences, e.g. using risk analyses and by participation in project meetings, offshore inspections, etc.	
Priority commissioning of fire detection and fire alarm systems, fire extinguishing system, etc. for the turbine	very good	4	medium risk	This aims at adequate fire protection just for the commissioning to protect persons and property Among other things especially for the case that no-one is on-site during commissioning and an increased fire load could be present and e.g. the effects of any assembly work (smouldering fires due to heat intensive tasks) is not detected early	
Use thermographic cameras during commissioning of electrical components to detect faults in planning or assembly	very good	2	low risk	The use of thermographic cameras during the commissioning of electrical components to detect weak points has been well tried	
Enough onshore tests Adequate securing of cargo Experienced and trained installation personnel and suitable installation equipment Supervising and testing QA during manufacture, assembly, and commissioning	very good	2	low risk		
Commissioning of the fire protection systems for the wind turbine prior to the overall commissioning of it	very good	4	medium risk		
Priority commissioning of the machine guards and the emergency functions of the turbine	adequate	6	medium risk	In order to exclude any damage by switching errors, incorrect programming or operating, the machine guards should be set to work immediately upon erection The same applies to the emergency functions of the turbine, e.g. alignment in the wind of the nacelle during a storm	

9.7.8	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	n)	Commissioning in general	Missing tools, material, etc.	high
	n)	Overall commissi-oning of the wind turbine together with the wind farm	Control room not yet finished / ready for test Control technology faulty	medium
	n)	Overall commissi-oning of the wind turbine together with the wind farm	External mains connection not yet in working order	high
	n)	Overall commissi-oning of the wind turbine together with the wind farm	External mains connection not yet in working order	high
	n)	Overall commissi-oning of the wind turbine together with the wind farm	Documentation not yet on hand (e.g. certificate BGV A3, circuit diagrams, maintenance instructions, etc.)	medium
	n)	Overall commissi-oning of the wind turbine together with the wind farm	Start-up personnel not sufficiently qualified	high
	n)	Overall commissi-oning of the wind turbine together with the wind farm	Weather and sea conditions not optimum	medium
	n)	Supervision of start-up by the certifiers	Missing resources at the certifier	high
	n)	Supervision of start-up by the certifiers	Qualification of certifier and/or the persons involved	medium
	n)	Supervision of start-up by the certifiers	Delay of commissioning due to insufficient co-ordination by certifiers and customer	medium

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.8
Prepare exactly Simulate the sequences Plan the tests and trainings on prototypes, material reserves, and tools in advance	adequate	6	medium risk		
Time schedule to be synchronised with the overall project schedule Early co-ordinate the work to be done	adequate	4	medium risk	Information to group 1 ▪ sub-station	
Time schedule to be synchronised with the overall project schedule	poor	9	high risk	Information to group 1 ▪ Sub-station	
Early plan emergency power (e.g. emergency generators etc.)	adequate	6	medium risk	The project schedule should allow for the power supply required to maintain circuit integrity, particularly for the emergency functions of the wind turbine	
Early schedule documentation and corresponding documents Make the start-up personnel and the operating personnel as well as the QA check the documentation to find errors If required, subject submittal of documents to penalties	adequate	4	medium risk		
Early hire personnel Train and instruct the personnel Proof of the employee's qualification when working for external service providers to be condition for deployment	adequate	6	medium risk		
Plan the weather slot for start-up according to the meteorological data and taking experiences into account Allow for sufficient buffer for bad weather / select alternative weather slot	adequate	4	medium risk	Normally, the overall project schedules are geared in the long run to the appropriate weather slots in the corresponding year	
Early synchronise resources and co-ordinate commissioning with the certifier to get hold of resources	adequate	6	medium risk	As only a limited number of certifiers is available in the market, book them early	
Early verify qualification (personal records etc.) of the test engineer involved Where required, turn down the project manager	adequate	4	medium risk		
Early co-ordinate the work to be done and the documents to be examined	adequate	4	medium risk		

9.7.8	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	n)	Tests of single components	Parts of components, incl. the corrosion protection, are faulty etc.	medium
	n)	Tests of single components	Inappropriate test carried out	small
	n)	Tests and inspection of machine safety devices	Damage to machine safety device due to test	small
	n)	Tests of single components	Faulty machine safety device	small
	n)	Tests and inspec-tion of connections and joints to the sub-station	Faulty connections (design)	small
	n)	Tests and inspec-tion of connections and joints to the sub-station	Injury to testing personnel, e.g. by overvoltage	high
	n)	Tests and inspection of the overall wind turbine (assumption: single wind turbine)	Defective components	small
	n)	Tests and inspection of the overall wind turbine (assumption: single wind turbine)	Injury to testing personnel	high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.8
Enough onshore tests Adequate securing of cargo Experienced installation personnel and suitable installation equipment Production supervision, permanent quality assessment	very good	2	low risk		
Clear specifications of test and testing criteria, to be laid down by the manufacturers Make QA and the certifier carry out the tests	adequate	2	low risk		
Test procedures well-tried and exactly defined Make experienced personnel carry out the tests Use appropriate testing equipment Correct execution of the tests (check lists)	adequate	2	low risk	The machine safety devices and the devices to maintain emergency functions are essential for functioning and to avert damage to a wind turbine	
Enough onshore tests Adequate securing of cargo Experienced installation personnel and suitable installation equipment Production supervision In-process quality assessment	very good	1	low risk		
Enough onshore tests Adequate securing of cargo Experienced installation personnel and suitable installation equipment Production supervision, permanent quality assessment	very good	1	low risk		
Sufficient protection measures within the scope of work safety Sufficiently experienced and qualified personnel	very good	3	low risk		
Enough onshore tests Adequate securing of cargo Experienced installation personnel and suitable installation equipment Permanent quality assessment	very good	1	low risk		
Sufficient protection measures within the scope of work safety Sufficiently experienced and qualified personnel	very good	3	low risk		

9.7.8	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	n)	Tests and inspection of the overall wind turbine (assumption: single wind turbine)	Inappropriate test to sufficiently test the overall wind turbine	small
	n)	Function tests, emergency functions (assumption: emergency power system on OSS AdÜ: operations support system?)	Defective components	small
	n)	Function tests, emergency functions (assumption: emergency power system on OSS AdÜ: operations support system?)	Injury to testing personnel	high
	n)	Function tests, emergency functions (assumption: emergency power system on OSS AdÜ: operations support system?)	Inappropriate test to sufficiently test the overall wind turbine	small
	n)	Machine protection not yet operational during commissio-ning of wind turbine	Machines damaged	medium
	n)	Function test of the entire system during operation	Defective components	small
	n)	Function test of the entire system during operation	Injury to testing personnel	high
	n)	Function test of the entire system during operation	Inappropriate test to sufficiently test the overall wind turbine	small
	n)	Function test of the entire system during operation	Delay caused by ambient conditions (bad weather, poor winds, etc.)	high

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.8
Clear specifications of test and testing criteria, to be laid down by the manufacturers Make QA and the certifier carry out the tests	adequate	2	low risk	See footing structure	
Enough onshore tests Adequate securing of cargo Experienced installation personnel and suitable installation equipment Permanent quality assessment	very good	1	low risk		
Sufficient protection measures within the scope of work safety Sufficiently experienced and qualified personnel	very good	3	low risk		
Clear specifications of test and testing criteria, to be laid down by the manufacturers Make QA and the certifier carry out the tests	adequate	2	low risk		
Early commissioning, in any case prior to the commissioning of the wind turbine as mentioned in the beginning of project stage 2	adequate	4	medium risk		
Enough onshore tests Adequate securing of cargo Experienced installation personnel and suitable installation equipment Production supervision, permanent quality assessment	very good	1	low risk		
Sufficient protection measures within the scope of work safety Sufficiently experienced and qualified personnel	very good	3	low risk		
Clear specifications of test and testing criteria, to be laid down by the manufacturers Make QA and the certifier carry out the tests	adequate	2	low risk		
Wait for appropriate weather slot and flexibly plan the resources (ships and persons) to ensure that the overall test passes off smoothly	adequate	6	medium risk		

9.7.8	Process steps (see legend)	Short description of operations	Explanation of risks	Risk assess-ment
	n)	Function test of the entire system during operation	Damage to electrical components (transformer, generator, switch-gears, etc.) due to overvoltage during test operation (e.g. by invalid switching on USP AdÜ?)	high
	n)	Acceptance of wind turbine by operating party and certifier	Missing resources at the certifier / contractor (operating party)	high
	n)	Mains connection of sub-station	Damage to switchgear when connecting the first time	medium
	n)	Overall commissio-ning of the wind farm as one component, also see sub-station	Delay caused by ambient conditions (bad weather, poor winds, etc.)	high

Legend
a) Execution planning of soil investigation for locations of offshore wind turbines
b) Soil investigation for locations of offshore wind turbines
c) Execution planning of the inland transport (overland and rivers) from the factory to the offshore port
d) Execution planning of the storage in the offshore port and the onshore assembly there
e) Execution planning of offshore transports
f) Execution planning of offshore erection
g) Execution planning of residual assembly work offshore
e) Execution planning of the commissioning and the test run until getting the PAC
i) Inland transport (overland and rivers) from the factory to the offshore port
j) Storage in the offshore port and the onshore assembly there
k) Offshore transports
l) Offshore erection
m) Residual assembly work offshore
n) Commissioning and test run until getting the PAC

Protection measures	Assessment of protection measures	Relevance	Status	Comments	9.7.8
Properly design, dimension, and establish the entire integrated electrical system Calculate and simulate potential switching procedures Co-ordinate planning with grid operator and comply with connection conditions	adequate		low risk		
Early synchronise resources and co-ordinate commissioning with the certifier to get hold of resources	adequate	6	medium risk		
Sufficiently experienced and qualified installation personnel Enough onshore tests	adequate	4	medium risk	Interface to sub-station	
Wait for appropriate weather slot and flexibly plan the resources (ships and persons) to ensure that the overall test passes off smoothly	adequate	6	medium risk	Interfaces with wind turbine, cable, and sub-station to be cleared up, commissioning from control room, offshore or onshore	

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