BUNDESAMT FÜR
SEESCHIFFFAHRT
UND
HYDROGRAPHIE

Standard Design

Minimum requirements concerning the constructive design of offshore structures within the Exclusive Economic Zone (EEZ)

BUNDESAMT FÜR
SEESCHIFFFAHRT
UND
HYDROGRAPHIE

Standard Design

Minimum requirements concerning the constructive design of offshore structures within the Exclusive Economic Zone (EEZ)

1. Update
28 July 2015 – Corrected as of 1 December 2015

The hereunder mentioned persons were involved in preparing this update:

Prof. Dr.-Ing. Martin Achmus
Dipl.-Ing. Angelika Alpen
Dipl.-Ing. Heino Axnick
Dipl.-Ing. Stefan Baars
Dr. Glenn Bannister
Dipl.-Ing. Daniel Bartminn CEng MICE
Dr.-Ing. Matthias Baeßler
Dipl.- Ing. Joachim Berger
Dipl.-Ing. Tim Bethke
Dr.-Ing. Florian Biehl
Dr. rer. nat. Günter Binder
Dr.-Ing. Mario Binder
Michael Cunitz
Dipl.-Ing. (FH) Jan Ole Degenhardt
Dipl.-Ing. (FH) Thomas Dietz
Dipl.-Ing. Klaus Ulrich Drechsel
Candy Drescher
Dr.-Ing. Björn Frettlöhr
Wirt.-Ing. (BA) Fabian Fuchs
Dr.-Ing. Galal Galal
Dipl.-Ing Jana Gehrmann-Vorbau
Dr. Birte Gerdes
Dipl.-Ing. Uwe Gierer
Dipl.-Ing. (FH) Bernd Grählert
Dipl.-Ing. Harald Grützmacher
Dipl.-Ing. (FH) Matthias Gutgesell
Dr.-Ing. Gerrit Haake
Dipl.-Ing. Thomas Hartig
Dipl.-Ing. Dieter Heller
Prof. Dr. Gert Hentschel
Dr.-Ing. Ulf Hinterscheid
Dipl.-Ing. (FH) Sven Höpfner
Dr.-Ing. habil. Yifeng Hu
Dr.-Ing. Ulrich Jäppelt
Dipl.-Ing. (FH) El-Hossein Khalife
Dipl.-Ing. Mussie Kidane
Dr.-Ing. Fabian Kirsch
Dipl.-Ing. Marcus Klose
Dipl.-Ing. Markus Kochmann
Dipl.-Ing. Thorsten Köpke
Dipl.-Ing. Björn Kramer
Dipl.-Ing. Matthias Laatsch
Dipl.-Ing. Sascha Lindemann
Dr.-Ing. Falk Lüddecke
Dipl.-Ing. Volker Mahlmann
Ulrich Maier
Dipl.-Ing. Manuela Medrow
Dipl.-Ing. Frank Mester
Dipl.-Ing. (FH) Victor Moor
Dr.-Ing. Matthias Portmann
Dipl.-Ing. Matthias Römer
Dir. Prof Dr.-Ing. Werner Rücker
Prof. Dr.-Ing. Stavros Savidis
Dipl.-Ing. Rüdiger Scharff
Prof. Dr.-Ing. Peter Schaumann
Dipl.-Ing. Madeleine Schmidt
M.Sc. Elena Schäfer
Dipl.-Ing. (FH) Axel Schweighardt
Dr.-Ing. Marc Seidel
Prof. Dr.-Ing. Michael Siems
Herr Caspar Stein
Dr. Constantijn Steinhusen
Michael Still
Dr.-Ing. Hendrik Sturm
Hinnerk Sunderdiek
Dipl.-Ing. Marcus Thiele
Dipl.-Ing. Eckart Tippelmann
Dipl.-Ing. Jörn Uecker
Dr. Michael Umbreit
Jorge Vallebueno
B. Eng. Sergej Warkentin
Christoph vor dem Brocke
Dr.-Ing. Felix Weise
Dr.-Ing. Florian Tom Wörden

Workgroups:

- Global design construction
  Management: Prof. Dipl.-Ing. Peter Dalhoff
- Global design offshore locations
  Management: Dipl.-Ing. Malte Lossin
- Safety engineering (offshore locations)
  Management: Dipl.-Ing. (FH) Anja Rasche
- Operation and recurrent examinations (offshore locations)
  Management: Dr. Björn Heise
- Technical equipment topside (offshore locations)
  Management: Dipl.-Ing. Thomas Köther
- Foundations/Geotechnics
  Management: Prof. Dr.-Ing. Harry Harder
- Supporting structures
  Management: Prof. Dipl.-Ing. Horst Bellmer
- Implementation, operation, and disassembly
  Management: Dipl.-Ing. Hans Kahle
- Standards, terms, and definitions
  Management: Dipl.-Ing. Christian Nath
- Editorial
  Management: Dipl.-Phys. Andreas Puls

BSH No 7005

Cover pictures authorized by:
Global Tech I, WindMW and German Federal Police

Translation by Jutta Zollt (http://jutta-zollt.de/ or rather http://jutta-zollt.com/)

Content

Abbreviations

AC	Alternating Current
ALARP	As low as reasonably practicable
ALS	Accidental Limit State
ArbSchG	Arbeitsschutzgesetz – German Labor Protection Act
BAM	Bundesanstalt für Materialforschung und -prüfung – Federal Institute for Materials Research and Testing
BAS	Burial Assessment Study
BauPG	Bauproduktengesetz – German Construction Products Act
BAW	Bundesanstalt für Wasserbau – Federal Waterways Engineering and Research Institute
BFO	Bundesfachplan Offshore – Spatial Offshore Grid Plan
BMVI	Bundesministerium für Verkehr und digitale Infrastruktur – German Federal Ministry of Transport and Digital Infrastructure
BSH	Bundesamt für Seeschifffahrt und Hydrographie – German Federal Maritime and Hydrographic Agency
BÜV	Bauüberwachungsverein – Association for Structural Engineering
CCP	Cathodic corrosion protection
CIGRE	Conseil International des Grands Réseaux Électriques – International Council on Large Electric Systems
CMS	Condition Monitoring System
DC	Direct Current
DGGT	Deutsche Gesellschaft für Geotechnik e. V. – German Geotechnical Society
DIBt	Deutsches Institut für Bautechnik – German Center of Competence in Civil Engineering
DIN	Deutsches Institut für Normung – German Institute for Standardization
DLC	Definition of the load case
DNV	Det Norske Veritas
EA-Pfähle	Empfehlungen des Arbeitskreises „Pfähle“ – Book of recommendations elaborated by the “Piles” study group of the German Center of Competence in Civil Engineering
EC	Eurocode (Series DIN EN 199x)
EEZ	Exclusive Economic Zone
EIA	Environmental Impact Assessment
EN	Euronorm
EV	Entwurfsverfasser – Architect
EWM	Extreme wind speed model
EXC	Execution Class

FLS	Fatigue Limit State
FPGt	Fachplaner für Geotechnik – Planning Expert for Geotechnics
GDWS	Generadirektion Wasserstraßen und Schifffahrt – Waterways and Shipping Directorate General
GL	Germanischer Lloyd
GTE	Geotechnics Expert
HAZID	Hazard Identification Study
HAZOP	Hazard and Operability Study ("PAAG" process: Forecast, cause localization, effect evaluation, reaction)
HOAI	Honorarordnung für Architekten und Ingenieure – German Code for Architects' and Engineers' Fees
IEC	International Electrotechnical Commission
IIW	International Institute of Welding
LAT	Lowest astronomical tide
NA	National Annex
NDT	Non-destructive testing
OM	Operation Manual
OS	Offshore Standard
OSS	Offshore Substation
OVC	Offshore vehicle coordinator
PEG (arch.)	Planning Expert for Geostatics on behalf of the architect
PPVO	Landesverordnung für Prüfingenieurinnen und Prüfingenieure – Authorised Inspectors and inspection Engineers Ordinance
QM	Quality Management
QA	Quality Assurance
RECOFF	Recommendations for design of offshore wind turbines
RNA	Rotor/nacelle assembly
RP	Recommended Practice
SCADA	Supervisory Control and Data Acquisition
SeeAnlV	Seeanlagenverordnung – Marine Facilities Ordinance (Regulation concerning offshore structures situated at the limit of the German territorial waters)
SEL	Sound exposure level
SLS	Serviceability Limit States
SWE	Special welding engineer
WS	Welding Specialist
StUK	Standarduntersuchungskonzept – Standards for Environmental Impact Assessments "Investigation of the impacts of offshore wind turbines on the maritime environment" by BSH

SVGt	Sachverständiger für Geotechnik – Geotechnics Expert
TA	Technical Approval
ULS	Ultimate Limit States
UPS	Uninterruptible Power Supply
UT	Ultrasonic Testing
WGS 84	World Geodetic System 1984
WPQR	Welding Procedure Qualification Records
WPS	Welding Procedure Specifications
ZTV	Zusätzliche Technische Vertragsbedingungen – Additional Technical Terms of Contract
ZTV-ING	Zusätzliche Technische Vertragsbedingungen und Richtlinien für Ingenieurbauten – Additional Technical Terms of Contract and Guidelines for Civil Engineering Works

Part A: General

1 Introduction

This standard is intended to provide legal and planning security for the development, design, implementation, operation and decommissioning of offshore structures within the scope of the Regulation concerning systems situated at the limit of the German territorial waters *(Seeanlagenverordnung – SeeAnlV)*. It is dynamic and integrative in nature so that it will be possible to take account of new knowledge and developments as well as the need to incorporate standards that have not been included before in order to achieve standardisation of an overall system. Accordingly, supplementary information which has become known since the publication of the first version of this standard (in 2007) has now been implemented in this standard. Initial practical experience gained since the year of publication has led both the approval authority and the Federal Waterways Engineering and Research Institute (BAW) as well as the Federal Institute for Materials Research and Testing (BAM) to the conviction that a more detailed, systematic approach is required with regard to general verification management To this end, the standards contained in the various respective Eurocodes (EC) and the national equivalent implementation thereof are used to provide a uniform basis with the aim of providing an even higher level of legal clarity. In accordance with the requirements voiced by the industry, a detailed section on offshore stations for converters, substations and accommodation has now been compiled and integrated into this first update.

A range of representatives from expert bodies and institutions have been involved in developing this standard, and played a constructive role in its development – as was also the case with the previous version. Representatives of the business and scientific communities made valuable contributions. In addition, whilst the draft was being compiled, the BSH granted associations (German Offshore Wind Energy Foundation, German Offshore Wind Energy Forum, Association for Wind Turbines, WAB Wind Energy Agency, Association of German Machine and Equipment Manufacturers and the German Association of Shipbuilding and Marine Technology) and transmission system operators (TenneT Offshore GmbH and 50hertz Transmission GmbH) the opportunity to submit their comments and voice their objections in a specialist meeting and a hearing held in collaboration with BSH workgroup leaders and BAW and BAM advisors. Overall it has been possible to create and maintain a solid basis for constructive cooperation based on system security and the protection of the marine environment.

Note:
This standard describes the minimum requirements placed on the design and structural components of offshore structures for the use of offshore wind energy with respect to their structural integrity from the perspective of the approval authority: **It is not suitable as a basis for business tenders.**

The requirements set down in the licensing decisions shall remain unaffected hereby.

2 Fundamentals

2.1 Legal basis

Installations subject to approval under SeeAnlV shall meet the current state of the art; Art. 4, para. 1 SeeAnlV demands this both for the design and installation of the systems as well as for their operation.

In accordance with Art. 5 para. 2 SeeAnlV, the approval authority may approve individual installation measures or commissioning subject to the granting of respective approval upon confirmation that the prescribed requirements have been accordingly complied with. Upon request of the approval authority, this confirmation shall be submitted in the form of an expert opinion compiled by a recognised expert. For the purpose of this standard, this shall be the appointed inspector.

Accordingly, demonstrating compliance with the prescribed standards represents the basis for approval and for establishing that the design, installation and operation of the system conform with the regulatory requirements.

2.2 Subject matter of this standard

This standard regulates the structural components of offshore structures in the Exclusive Economic Zone (EEZ).

These include offshore wind turbines, cabling within the park, measurement masts, offshore stations and power transmission cabling systems.

The offshore structures, in particular offshore wind turbine and offshore station supporting structures, are considered both in terms of their individual components and as an overall system. The sections to be completed are basically divided into the following project phases which are described in more detail in Part B1 and Tables 1 (offshore wind turbines) and 2 (offshore stations):

- Development
- Design
- Implementation, i.e. production, loading transport, construction, resp. installation, commissioning
- Operation and
- Decommissioning.

The specification to comply with the state of the art or, failing that, the state of current scientific and technical progress, relates to the conclusion of each specific project phase, resp. in the case of the construction phase to the completion of each respective construction step. The individual project phases are concluded upon the granting of respective approval according to this Standard Design.

For each respective approval, verified documents must be submitted to the approval authority. Further details are described in Part B. The examination must be initiated by the applicant, resp. the approval holder who shall appoint an inspector in good time. This inspector shall then examine the documents with respect to their completeness, consistency and integrity, resp. plausibility. With the support of the BAM and BAW, the approval authority shall only subject the submitted documentation to a plausibility check.

2.3 Standard directives for approval practice

Approvals granted previously for materials regulated here contained directives that more explicitly defined the project, some of which can be viewed as standardising practice, even if they are subject to continuous examination in what is currently a dynamic development process.

These directives, including their justifications, are summarised below and incorporate the latest version of the standard incidental provisions – summarised for offshore wind turbines and offshore stations:

- The subjects of the approval are the installation and operation of individual offshore wind turbines, incl. ancillary facilities, such as cabling within the park and offshore stations for substations and possibly accommodation, resp. offshore converter stations and their respective power transmission cabling systems.

Justification:
This provision outlines and defines the type and scope of the subject of the approval in terms of both space and construction.

- The precise positions of the individual offshore structures shall be specified. The exact cable length in kilometres and depth (so-called „as-laid documentation") shall be specified.

  Following completion of the offshore structures, the approval authority shall be presented with an as-built drawing containing all the construction facilities installed, including their final geographic coordinates according to WGS 84.

  The as-built drawing for the cabling must contain the exact position and depth of the cables relative to the seabed at the time of taking the measurements and detail all intersections with submarine cables and pipes and include their respective geographic coordinates according to WGS 84.

Justification:
The purpose of this directive is to specify the subjects of the approval. As the exact structural design of the systems, resp. details regarding the laying of the cables, has not yet been finally decided at the time of approval, and, therefore, cannot be specifically represented at this stage, it is not possible to present respective construction plans. The documents to be presented, in particular the as-built drawing, incl. the measured positions, shall be considered as the basis for checking this approval following completion of the installations. These shall form the basis for all further procedures and shall become the subject of this approval.

- The design and equipment of each offshore structure shall meet the current state of the art. The same applies to the installation of these structures, incl. all measures to prepare for the construction work.

  In addition, construction engineering preparation of the foundation work and subsequent inspection of the system operation shall be in accordance with the Standard Ground Investigations. Minimum requirements for geotechnical surveys and investigations into offshore wind energy structures, offshore stations and power cables" published by the BSH. The development, design, implementation, operation and decommissioning of systems shall be in accordance with this "Standard Design – Minimum requirements concerning the constructive design of offshore structures within the Exclusive Economic Zone (EEZ)" published by the BSH. In each case, the current version of the respective standard shall be used as a basis. The same applies to the incidental provisions and directives. Deviations shall be submitted to the approval authority and their equivalence accordingly justified. The offshore structures must be examined according to the specifications contained in this Standard Design.

The documents submitted to the approval authority must be compiled in such a way as to ensure that compliance with the requirements set down in the Standard Ground Investigations and this Standard Design can be easily determined by a third expert body. The nature of the documents and verifications to be submitted – incl. examination and certification requirements – and the schedule for submitting these documents with respect to the installation of the systems, can be individually determined by studying the Standard Ground Investigations and this Standard Design.

Justification:
Compliance with the conditions to maintain state of the art quality standards as well as certification of the systems and components guarantees the structural safety of the system. The design and equipment variant that the approval holder intends to install, but which cannot however be determined at the time of approval, will then be checked by a third expert body to ensure that the normal quality requirements are satisfied. In this way, it will be possible to ensure that approval can be effectively issued without final, detailed construction and design drawings being available. These documents and verifications shall be presented within a specified appropriate period in order to allow them to be checked before the systems are installed. Earlier presentation of the documents is not only possible but also desirable in order for additional changes to be made if necessary. The Standard Ground Investigations contains minimum requirements that include concrete specifications for the geological, geophysical and geotechnical site survey. This standard is currently being updated. The current version shall be used in each case. The approval authority shall decide on deviations on a case-by-case basis and exclusively reserves the right to commission a assessment report from a recognised expert (Art. 5 para. 2 SeeAnlV) at the expense of the applicant.

- In addition to the requirements set down in the Standard Ground Investigations and this Standard Design, the following requirements must also be met when designing and building offshore structures:

  The structure shall be designed and configured in such a way that

  - during installation, operation or decommissioning occupational safety and fire safety provisions are accordingly observed,
  - no avoidable emissions of pollutants, noise and light into the marine environment can occur during installation or operation using state of the art technology, or, where such emissions are unavoidable and provided for in the safety requirements pertaining to marine and air transport – impairments shall be kept to a minimum,
  - in the event of collision with a ship, the hull of the ship shall be damaged as little as possible.
  - no electromagnetic waves are produced that could cause disturbance to common navigation and communications systems or the functionality of correction signal frequencies. The applicable limits are detailed in the current version of IEC 60945.

Wherever possible, the external paintwork shall be glare-free, notwithstanding the regulations on aviation and shipping identification.

The corrosion protection shall have the lowest possible level of pollutants. The use of tributyltin (TBT) is prohibited. In the splash zone, the (underwater) structure shall be painted using oil-repellent paint; it is not necessary to regularly remove marine growth in this connection.

For the above directives, the approval holders are required to present proof for the 2nd release in accordance with this Standard Design – at the latest upon commissioning of the system – that accordingly represents and includes the forecasts contained in the expert opinions on

- the materials used in and in the vicinity of the offshore structures and

– the emissions resulting from the specifically selected structural and equipment variant, in particular the type and scope of noise emitted into the water.

These documents shall become an integral part of the approval in, as far as these accordingly confirm, compliance with the respective incidental provisions. Reference is made here to the minimum requirements published by the BSH.

Justification:
The above directives serve to avoid both contamination and impairment of the marine environment and transport hazards in accordance with Art. 3 para. 1 SeeAnlV. As shown by the formulation on emissions avoidance, it may be difficult to reconcile the requirements imposed in order to protect the natural environment and those for the safety of shipping.

Whereas the requirement to provide a design with the greatest hull-retaining properties in the event of a collision between a ship and an offshore wind turbine serves to meet both the objectives defined in Art. 3 SeeAnlV simultaneously, in terms of light emissions, the safety requirements for shipping and aviation limit the ability to completely avoid emissions during the construction and operating phases.

As a result, there is a mandatory requirement to continuously optimise the installations in terms of ecological impact according to the latest technological findings and know-how to the extent that this is possible and reasonable based on indispensable safety measures.

Linking this requirement to meet the state of the art is intended to ensure that the design and equipping of the system is able to avoid, resp. reduce any effects which cannot be foreseen with certainty at the time of approval, but which if they were to occur later would lead to the cancellation or revocation of the approval. In the event that pollution, noise and light emissions cannot be avoided, this directive incorporates the minimisation of the resulting impairments in accordance with the precautionary principle. Examples here include the development and use of deterrent measures against animal species that are negatively affected, the use of the best available and most naturally compatible traffic safety beacons in the form of a self-regulating system that flexibly adapts the light intensity to visibility conditions, the use of the most environmentally friendly operating materials and the most comprehensive encapsulation system possible for pipes and containers that carry pollutants.

The aforementioned purposes are also served by the specific requirements for configuring corrosion protection and the colour scheme of the systems. The requirement pertaining to the system colour scheme is intended to avoid any dazzle effect due to unnecessary reflections on the smooth system surfaces. With respect to the corrosion protection of offshore installations, the BSH has meanwhile published a set of minimum requirements which have been integrated into this standard. The absence of pollutants, in particular, shall also be accordingly demonstrated in an emission report. In as far as valid minimum requirements are in place at the time of ordering the structural components, these are to be complied with. The requirement on using oil-repellent coatings in the area that comes into contact with the sea surface ensures that drifting oil in the area of the project will not adhere to the components which would prevent the oil from being recovered. This is intended to avoid a situation in which oil stuck to the structure would be steadily washed out into the water over a longer period of time.

In close connection with this, the anticipated emission of sound into the water should be mentioned as this is also subject to the prescribed minimisation requirement. The respective directive takes account of the possible exponential effect of noise emissions and how these can be avoided.

2.4 Additional standard specifications for offshore structures

The *"Standard Ground Investigations – Minimum requirements for geotechnical surveys and investigations into offshore wind energy structures, offshore stations and power cables"* in its current version, published by the BSH, represents an integral part of this code of practice.

The environmental impact assessment shall be drawn up using a project description for the common pile foundation types listed in the application based on the verified preliminary draft. In the case of new foundation types or foundation types not yet tested in the German EEZ, further documentation may be required.

Planning principle 5.3.2.9 set down in the Spatial Offshore Grid Plan (2K criterion) shall be observed. The existing standardised calculation method was included on the BSH Internet page as an addition to the current version of the Standard "Investigation of the Impacts of Offshore Wind Turbines on the Marine Environment (*StUK*)".

Safety and precautionary measures are defined in a separate regulation. A corresponding standard for a protection and safety concept may be incorporated. Structural requirements resulting from the provisions set down in the German Labor Protection Act (*ArbSchG*) incl. the German Construction Products Act (*BauPG*), the Product Safety Act (*ProdSG*) and their respective directives, as well as from the involvement of the responsible occupational safety organisations, must be taken account at an early stage of the development and construction phase. In this connection, the applicant, resp. approval holder, shall ensure right from the beginning that both an operational and occupational safety concept, as part of the overall safety and protection concept, and a fire protection concept are drawn up and regularly updated; with respect to the corresponding approvals, the appointed inspectors shall review both documents extensively with regard to structural considerations. With a view to fire protection issues, reference is herewith made to the information contained in the guidelines published by the German Insurance Association (*GDV*). The provisions stipulated by the Federal Ministry of Transport and Digital Infrastructure (*BMVI*) and the Waterways and Shipping Directorate-General (*GDWS*) on all issues related to transport safety remain unaffected hereby.

With respect to the observance of the 160 dB SEL noise limit at a distance of 750 m from the emission source during noise-intensive foundation work, respective noise-reducing measures – if required – shall be allowed for early on in the construction phase. The noise control concept, incl. the chosen work method and the considerations justifying this selection, as well as the planned imission-minimisation and/or damage prevention measures and the up-to-date noise forecast based on these measures, must be presented in writing to the approval authority together with the documentation required for the 2nd release for the purpose of examination. At the latest upon entering the 3rd release phase, the documents detailing the operational structure of the noise-reducing measures with respect to each of the foundation types to be applied must be submitted.

Generally, recognised rules of technology that already exist specifically for certain individual components or systems are listed as basic standard provisions in the corresponding regulation materials. If applicable to offshore structures, the provisions set down in the respective Eurocodes and German technical regulations shall take precedence. Omitted regulations can be supplemented from other codes of practice if these are analysed for admissibility by an expert. It is generally not allowed to mix different codes of practice. The combination or mutual supplementing of different or competing codes of practice, or of individual provisions therein, shall always be analysed for admissibility and assessed accordingly by an expert. The hierarchy of norms must be determined and presented at an early stage – as a rule together with the documents for the 1st release.

3 Deviations and amendments

The Eurocodes shall apply; in addition, the DIN standards in their respective latest white copy versions shall also be applied. The approval authority reserves the right to exclude individual standards or parts thereof from the obligation to apply the above standards.

Deviations from the standards and requirements established here are possible providing these are appropriate based on new knowledge in general or with regard to the specific features of the project, or serve the aforementioned protective purposes in at least an equivalent manner. These shall be marked accordingly and their equivalence justified vis-à-vis the approval authority. The approval authority reserves the right to consent to deviations and amendments and may engage an appropriate inspector accordingly.

A request for deviation shall be submitted by the applicant, resp. the approval holder, in a timely fashion so as to ensure that the decision, incl. the stipulations contained therein, may be integrated into the respective project schedule. All deviations shall be indicated accordingly; they must be justified and assessed by the appointed inspector.

The approval authority shall decide on the admissibility of a deviation on a case-by-case basis, whereby it exclusively reserves the right to commission an assessment by an appropriate assessor at the expense of the applicant.

The standards referred to in each respective section shall be supplemented by further codes of practice, regulations and recommendations, in as far as they do not take matters concerning the dimensioning of foundation elements and support structures for offshore structures into account.

Further technical codes of practice – in their respective current version – may also be referred to in cases where no regulations are stipulated in the above-mentioned provisions or where, due to the special nature of offshore structures, these either cannot be applied or cannot be applied practically.

With respect to the application of codes of practice that contain offshore-specific deviations from, resp. amendments to, the German and European standards quoted above in the respective sections, the following procedural principles shall apply:

- All deviations shall be submitted to the approval authority and accordingly justified and represented in detail. These requests must also contain a statement as to the equivalence of the chosen approach with that specified in the standard. The deviation request must be assessed by the appointed inspector.
- All amendments shall be submitted to the approval authority, accordingly justified and represented in detail and must be analysed for admissibility by an expert. The amendment request must be assessed by the appointed inspector.

4 Updating

This standard represents the current state of the art or, failing that, the state of current scientific and technical progress. As the future implementation of further projects, in particular, is expected to generate new knowledge and lead to further technical developments, this standard shall be adapted in line with ongoing developments at appropriate intervals of time.

5 Interim regulation

1. The 1st update of this Standard Design shall become applicable to all procedures provided for in SeeAnlV upon the lapse of a six-month period following the day of publication, in as far as complete documents for the 1st release of the respective systems have not been submitted to the BSH prior to this point in time. Should the BSH conclude that the documents are incomplete, the applicant shall be granted a 3-month period from the date of receiving notification of the incompleteness to hand in these documents in arrears, resp. to complete said documentation.

   Exempt from this regulation are the provisions related to maintaining the operating permit. The regulations governing status meetings during the operating phase, the content of the operating manual and the concept for and implementation of periodic examinations according to the test plans shall be applied starting on the day of publication.

2. For all procedures in which the version of this Standard Design dated 17. 6. 2007 may still be applied, this regulation shall only apply if the verified documents for the 2nd release are submitted to the BSH within the 24-month period following the day of publication of this 1st update. Should the BSH conclude that the documents are incomplete, the applicant shall be granted a 6-month period from the date of receiving notification of the incompleteness to hand in these documents in arrears, resp. to complete said documentation, whereby the application of this 1st update of this Standard Design shall not be deemed mandatory.

Part B Verifications and approval requirements

1 Timescale and site conditions

1.1 Preliminary remarks

The minimum requirements set down in this standard relate to the design and structural components of offshore structures for the use of offshore wind energy.
These include, in particular

- The locally fixed integration into the seabed (foundation elements),
- The support structure (in the case of offshore wind turbines: the tower and substructure, in the case of offshore stations: substructure, possibly incl. supporting components of the operational structure),
- Operational structure (in the case of offshore wind turbines the rotor/nacelle assembly, consisting of the nacelle, hub and rotor blades, in the case of offshore substations the "topside" installation),
- The cabling of the individual installations within the park, including their linkage to the substation,
- The power export system from the offshore substation to the grid connection on land via the offshore converter station and
- All other offshore facilities (e. g. measurement masts, accommodation platforms) that are part of the offshore wind farm.

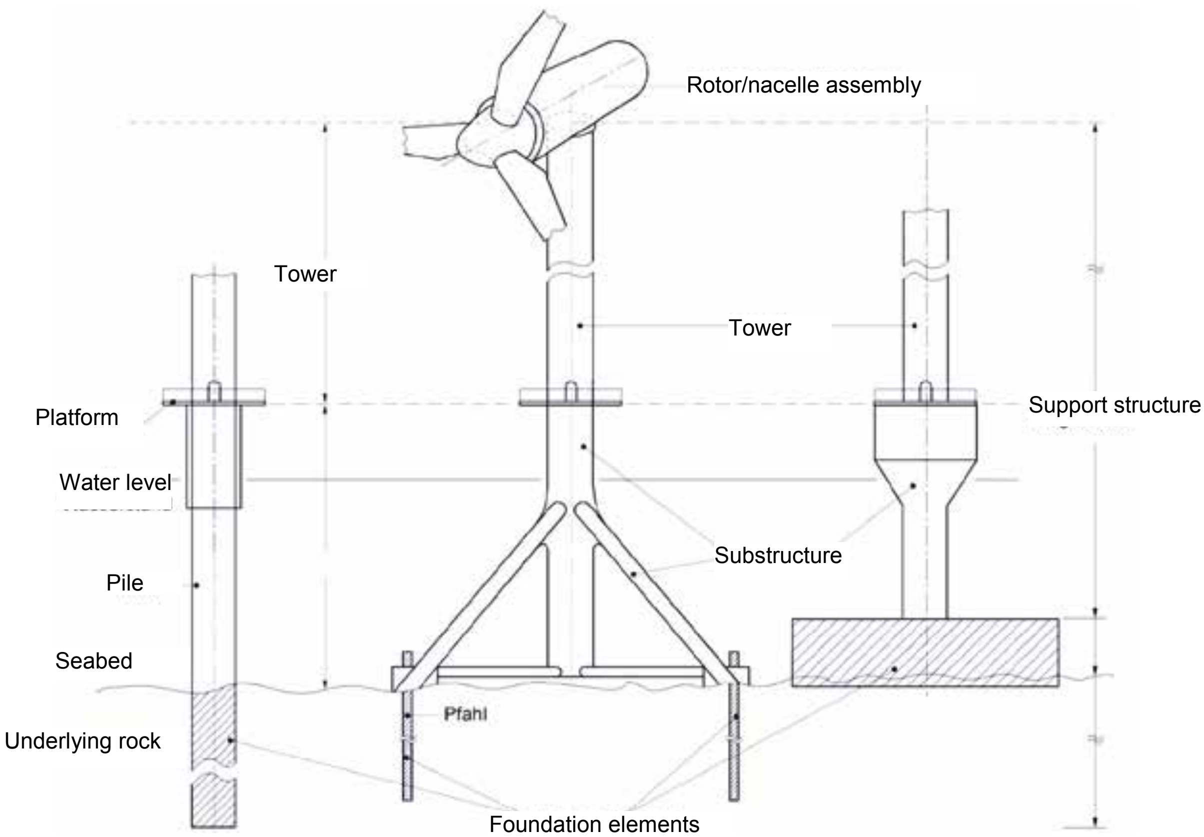


Figure 1-1: Components of the overall mechanical system of an "offshore wind turbine".

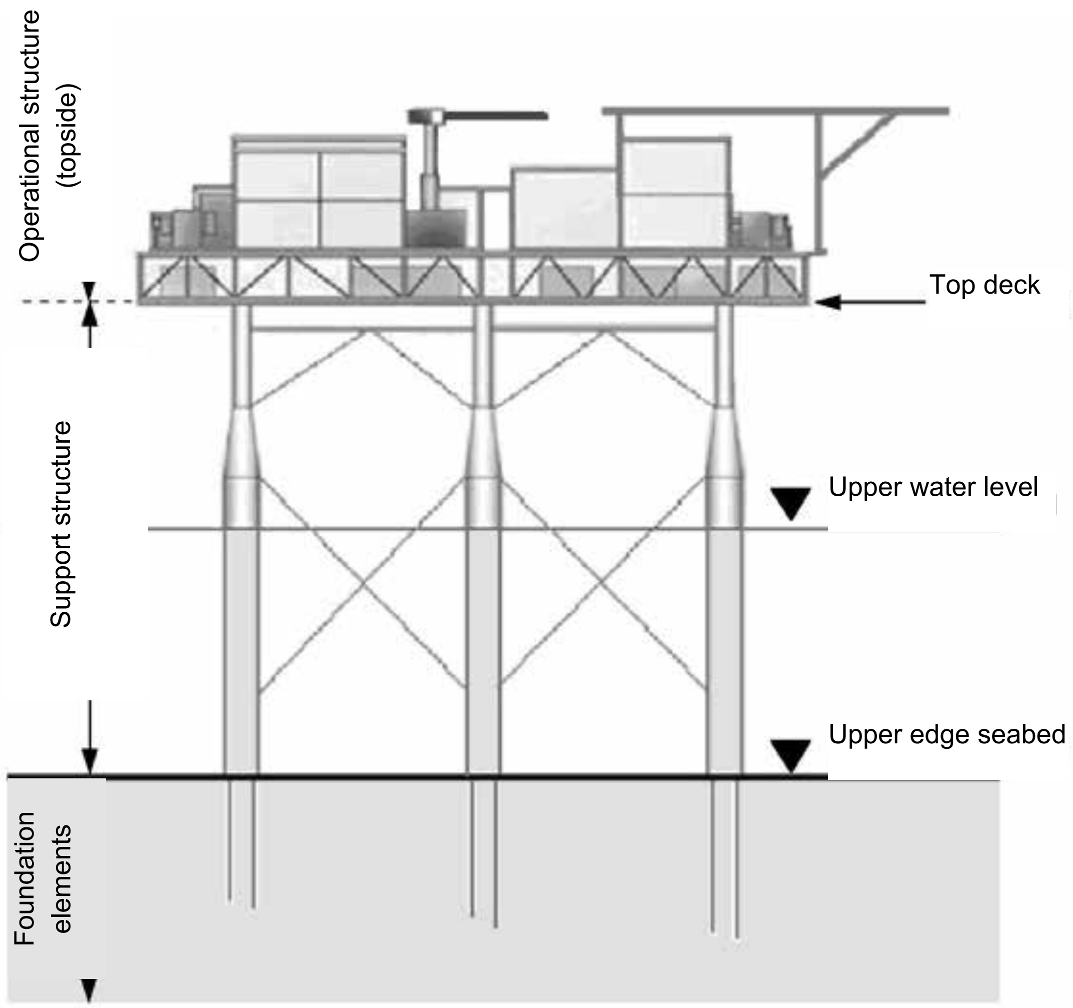


Figure 1-2: Components of the overall mechanical system of an “offshore station”.

This is the case, for example, when measuring the natural frequencies and loading assumptions of the offshore wind turbine.

The test procedure principally includes the following elements and steps:

(1) Type certificate for the rotor/nacelle assembly in the case of an offshore wind turbine; in the case of an offshore station the functional description and design concept,

(2) Examination of the design basis, incl. site-specific conditions, such as the subsoil properties (site assessment),

(3) Test of the site-specific loading assumptions and the support structure as well as the foundation elements (site-specific design evaluation),

(4) In the case of an offshore wind turbine: Examination to determine that the type certificate (1) for the rotor/nacelle assembly actually incorporates all the site-specific conditions; in the case of an offshore station: Update and more detailed specification of the respective concepts,

(5) Certificate of conformity/verification report for the site-specific design of the offshore structures following completion of items (1) to (4),

(6) Test and evaluation of the facilities for inspecting offshore wind turbines as an overall system (Supervisory Control and Data Acquisition, SCADA, including the Condition Monitoring System, CMS, for the rotor/nacelle assembly);

(7) Test and evaluation of sea operations and the decommissioning concept,

(8) Production and installation monitoring,

(9) Inspection of loading and transport from the quayside to the installation site, installation and commissioning,

(10) Certificate of conformity and verification report for the monitoring services following completion of items (6) to (9),

(11) Project certification in accordance with this standard,

(12) Periodic inspections in order to maintain the operating permit and

(13) Inspection and monitoring of the decommissioning phase and issue of the respective certificate of conformity, resp. test certificate.

It is highly recommended to engage an appointed inspector – and to exchange information with this inspector – at an early stage so as to be able to coordinate the design basis (determining the site conditions, incl. the subsoil situation and which regulations and methods apply to the design basis) with this appointed inspector as early as possible.

1.2 Language

The official language is German. All documents which are or shall be deemed binding during the approval process before the approval authority, must be submitted in the German language. This shall apply, in particular, to all reports and documents compiled by the appointed inspector (verification reports, monitoring reports, certificates of conformity, etc.).

As a rule, technical documentation may be submitted in English.

1.3 Timescale

1.3.1 Preliminary remarks

The timescale for realising an offshore structure project can generally be divided into the following phases (project phases):

- Development
- Design
- Implementation
- Operation and
- Decommissioning.

Table 1-1 summarises the timescale for offshore wind turbines. Each phase includes a definition of the overriding objectives to be achieved by the end of each respective phase. The first two phases (Development and Design) differentiate between three different types of document:

Basic documents: Documents which contain information on the conditions established and measured at the site.

Design rules: Regulations, standards, guidelines and approaches that define how the site conditions are to be applied – including dimensioning and design – from an engineering perspective. These represent the design basis for the respective offshore structures.

Planning results: Computed results and verifications, drawings, specifications and implementation notes based on the design rules and basic documents.

A list of the minimum required documents is included at the end of each technical section; additional documents shall be submitted or submitted in arrears on a case-by-case basis. Each technical section in itself is a complete representation of all the individual project phases detailed above.

All technical documents shall be inspected by an appointed inspector prior to being submitted to the approval authority. In each respective project phase, the required documents shall be compiled by the appointed inspector and submitted to the approval authority for a plausibility check and approval, together with the required technical documentation, in good time. In addition, the applicant, resp. the approval holder, must ensure that the approval authority is involved throughout all the respective project phases.

Table 1-2 summarises the timescale for the installation of the operational structure. It is important to point out here that the timescale recommended for the installation of the operational structure varies from that to be used for the support structure, resp. offshore wind turbine. The reason for this is that the functionality strived for to meet operational management, safety and emergency system demands directly affects the design and should, therefore, be specified early on in the project. This, however, does not entail detailed plans as required for the 2nd and 3rd releases.

1.3.2 Development phase

During the development phase, the site conditions are to be sufficiently recorded so as to allow an assessment of the basic technical feasibility of the project. Based on this, a preliminary design of the possible foundation variants being considered by the developer can be drawn up. This should include the environmental impact and "collision friendliness".
All site-specific data should be compiled in the basic documents.

<table>
<tr><th>Phase</th><th>Objectives</th><th>Chapter</th><th>Appointed inspector</th><th>Approval authority</th></tr>
<tr><td>Development</td><td>Compilation of the site-specific data

Determination of the design basis

Preliminary design</td><td>1
1.3.2
2.2
3.2
4.2</td><td>Verification report and certificate of conformity</td><td>Plausibility check*

Preliminary design approval

(1st release, poss. incl. special measures)</td></tr>
<tr><td rowspan="3">Design</td><td>Final specification of the subsoil model for each offshore wind turbine site and the offshore station

More detailed specification of the design basis</td><td rowspan="3">1.3.3
2.3
3.3
4.3</td><td>Verification report and certificate of conformity</td><td rowspan="2">Plausibility check*

Design approval

(2nd release, poss. incl. special measures)</td></tr>
<tr><td>Final design of the primary and secondary support structures</td><td>Verification report and certificate of conformity</td></tr>
<tr><td>Installation, operation and decommissioning planning</td><td>Verification report and certificate of conformity</td><td>Plausibility check*

Implementation approval (3rd release, poss. incl. special measures)</td></tr>
<tr><td rowspan="5">Implementation</td><td>Production</td><td rowspan="5">1.3.4
2.4
3.4
4.4</td><td>Inspection reports and certificate of conformity pertaining to the monitoring of the production phase</td><td rowspan="5">Plausibility check*

Operating release (poss. incl. special measures)</td></tr>
<tr><td>Transport</td><td>Inspection reports and certificate of conformity pertaining to the monitoring of the transport phase</td></tr>
<tr><td>Erection / installation</td><td>Inspection reports and certificate of conformity pertaining to the monitoring of the erection/installation phase</td></tr>
<tr><td>Commissioning</td><td>Inspection reports and certificate of conformity pertaining to the monitoring of the commissioning phase</td></tr>
<tr><td>As-built drawing,

Operations manual,

Test and inspection plan for periodic inspections</td><td>Verification reports pertaining to the as-built drawing, operations manual and test and inspection plan for periodic inspections

Project certificate</td></tr>
<tr><td>Operation</td><td>Operation, maintenance and monitoring</td><td>1.3.4
2.5
3.5 4.5</td><td>Periodic inspections verification report and certificate of conformity</td><td>Plausibility check*
Maintenance or temporary revocation of the operating permit</td></tr>
<tr><td rowspan="2">Decommissioning</td><td>Decommissioning planning</td><td rowspan="2">1.3.6
2.6
3.6
4.6</td><td>Verification report and certificate of conformity pertaining to the decommissioning plan</td><td>Plausibility check*
Decommissioning release (poss. subject to specific requirements)</td></tr>
<tr><td>Carrying out decommissioning</td><td>Inspection reports and certificate of conformity pertaining to the decommissioning phase</td><td>Plausibility check*
and declaration stating that the measures have been completed</td></tr>
</table>

Table 1-1: Timescale for offshore wind turbines

* Plausibility check carried out by the BSH, together with the BAM and BAW, and possibly a specially appointed inspector.

Phase	Objectives and measures	Chapter	Documents to be compiled by the approval holder and submitted to the BSH	Documents to be compiled by the appointed inspector and submitted to the BSH	Approval authority
Development	Compilation of basic documents for the fundamental concept (functional description) of the offshore station with respect to its usage, safety and marine environmental protection measures	5.1		Verification report (based on the basic documents)	Plausibility check 1st release (poss. incl. special measures)
	Compilation of the site-specific data Site assessment of the foundation structure	1.3.2 2.2 3.1 3.2	Geological report (in as far as this is required by the Standard Ground Investigations) Subsoil inspection report Subsoil and foundations survey Meteorological and oceanographic expert opinion	Verification report and certificate of conformity	
	Determination of the design basis	2.2 5.2	Design basis • Specification of the hierarchy of norms • Description of the functional specifications and requirements placed on the primary and secondary support structures		
	Preliminary design of the support structure (incl. verifiable measurements of the planned foundation structures for the EIA)	2.2	Preliminary design and support structure	Verification report (technical statement)	
Design	Update of the basic documents through the provision of detailed concepts: • Load handling concept • Fire and explosion protection concept • Access concept • Room utilisation plan	5.3.1		Verification report (based on the basic documents)	Plausibility check 2nd release (poss. incl. special measures)
	Update of the site-specific data	3.3	Ground investigation report Subsoil and foundations survey Geotechnical design report Poss. report on the implementation of a dynamic pile load test Poss. confirmation of the feasibility of a dynamic pile load test	Verification report and certificate of conformity	
	Update of the design basis	2.3	Update of the design basis	Verification report and certificate of conformity	
	Final design of the primary and secondary support structures	2.3	Final design of the primary and secondary support structures	Verification report and certificate of conformity	

Phase	Objectives and measures	Chapter	Documents to be compiled by the approval holder and submitted to the BSH	Documents to be compiled by the appointed inspector and submitted to the BSH	Approval authority
Design	Update of the basic documents through more detailed specification of the concepts: • Specification of the fire compartments of the operational structure (topside) • Description of the active and passive fire-fighting systems • Specification of the transport and access systems for the support structure and operational structure installations • Update of the operational concept and offshore station design • Finalisation of the fire protection concept for the offshore station • Finalisation of the equipment concept for the offshore station • Implementation of the structural requirements pertaining to the offshore station based on the safety and functional demands resulting from the risk assessment • Finalisation of the final transport and access concept	5.3		Verification report (based on the basic documents)	Plausibility check 3rd release (poss. incl. special measures)
	Final installation design	2.3.4	Installation manual	Verification report	
	Finalisation of the final design for installing the offshore station, incl.: • Compilation of a commissioning concept • Presentation of reports on all the tests conducted • Detailed description of the transport and installation procedures Compilation of an implementation concept • Compilation of the towing procedures • Transport and installation procedures	2.3.5		Verification report	
	Decommissioning concept	1.3.3	Decommissioning concept	Verification report and certificate of conformity	

Phase	Objectives and measures	Chapter	Documents to be compiled by the approval holder and submitted to the BSH	Documents to be compiled by the appointed inspector and submitted to the BSH	Approval authority
Implementation	Production and assembly monitoring, Examination of the QM certificates provided by the manufacturers Compilation of NDT reports, incl. monitoring of the transport, erection and installation and commissioning phases	2.4		Inspection reports and certificates of conformity pertaining to the monitoring of the production and assembly, transport, installation and commissioning phases	Plausibility check Operating release (poss. incl. special measures)
	As-built documentation	2.4.2.3	As-built construction drawing	Verification report and certificate of conformity	
	Operations monitoring	1.3.5 2.4.3 2.5.3	Test and inspection plan for periodic inspections	Verification report and certificate of conformity	
		2.4.3	Operations manual	Verification report and certificate of conformity Project certificate	
Operation	Periodic inspections	1.3.5 2.5 3.5 5.5		Verification report and certificate of conformity	Plausibility check Maintenance of the operating permit
Decommissioning	Decommissioning plan	2.6 3.6	Detailed description of the decommissioning procedure	Verification report and certificate of conformity	Plausibility check Declaration confirming that decommissioning and disposal have been carried out correctly
	Monitoring of the decommissioning phase, the disassembly of the components, their transport and disposal	2.6	Disposal verifications	Inspection reports and certificate of conformity	

Table 1-2: Timescale for offshore statios

The basic documents also include meteorological and oceanographic expert opinions that provide the following basic data:

- Water levels,
- Scatter diagrams illustrating the relevant wave heights,
- Wind, wave and poss. ice parameters,
- Correlation of wind, waves and poss. ice drift,
- Currents,
- Bathymetry,
- Sea water characteristics (density, salt content, temperature bandwidth etc.),
- Conditions that influence scouring,
- Growth and
- Conditions that influence corrosion.

The hull-retaining properties of the support structure of an offshore structure in the case of a collision must also be accordingly demonstrated (“collision-friendliness”). Special assessment criteria apply to offshore stations with regard to ensuring the best-possible design of the support structure with regard to its hull-retaining properties (please refer to chapter B2.1.1).

The design rules are defined in the design basis, whereby the design standards and regulations to be applied, together with their hierarchy with respect to the final design of the offshore structure, shall be clearly stipulated. It should be easy to derive which code of practice should be applied in the case of each respective certification. The hierarchy of standards also takes account of the issues resulting from the implementation phase and places particular importance on the requirements posed by an “offshore” location. Furthermore, the functional specifications and requirements placed on the primary and secondary support structures of offshore wind turbines and offshore substations shall be defined accordingly.
Planning results must also be presented alongside the basic documents and design rules. The preliminary planning results include a detailed project description.
The project description includes the following information:

- Preliminary wind farm layout (the locations of the offshore wind turbines, offshore station and all other poss. structures),
- The approach path to the helicopter landing pad (in as far as one is planned),
- Preliminary cable layout,
- Basic information on the planned foundation concepts:
  - Max. required space,
  - Max. required surface area,
  - Estimate of the net flow cross-section,
  - Max. expected seabed penetration,
- Basic system data:
  - System type (e.g. “three-rotor, windward runner, variable speed control with adjustable rotors”),
  - Max. hub height, max. rotor diameter, max. rated output of the offshore wind turbine,
- Basic offshore station information:
  - Intended purpose (converter, substation, accommodation etc.),
  - Max. dimensions of the offshore station,
  - Basic information on the planned foundation concepts (please refer to the above).

The project description forms the basis for the environmental impact assessment which will rest on the foundation concepts under consideration.

The exact specifications of the offshore wind turbine do not need to be final at this stage. However, the max. size, resp. the bandwidth with respect to the above-mentioned basic system data, must be stated. Preliminary loading assumptions are only required for an offshore wind turbine in as far as these are required for the preliminary design of the foundation concept. The development phase is complete upon the award of the preliminary design approval (1st release).

1.3.3 Design phase

All tasks incorporated into the "Design" phase of the project are divided into three stages.

During the first stage, the design basis and the subsoil model are finalised for each site where an offshore structure is to be located (e.g. offshore wind turbine or offshore station site). The minimum requirements pertaining to the content of the basic documents, the design rules and the planning results can be reviewed in the respective technical sections of this document.

The basic documents, the design rules and all other planning results must be examined by the appointed inspector. This radically increases planning security for the second stage, the detailed design of the primary and secondary support structures, in that the design basis and the site-specific boundary conditions have already been inspected and finalised.

The final design of the primary and secondary support structures is completed during the second stage. During this stage, no further basic documents are compiled. However, the design rules may be updated. During this stage, the emphasis is on specifying the planning results.

The third and last stage of the "Design" project phase is aimed at completing the plans for installing, operating and decommissioning the structure. No further basic documents will be compiled at this stage. Neither will modifications be made to the design rules.
The following planning results must be achieved:

- Installation manual
- Operations manual
- Decommissioning concept.

The offshore wind farm design phase is complete upon the award of the implementation approval (3rd release).

1.3.4 Implementation phase

The implementation phase is divided into the following stages: Production, transport, installation and commissioning. These must be subjected to independent inspections and accordingly documented by an appointed inspector

At the end of each stage, the appointed inspector shall issue a certificate of conformity summarising the inspection reports. The project certificate is issued together with the certificate of conformity pertaining to the monitoring of the commissioning phase and upon presentation of all other required certificates of conformity.

The monitoring services shall be commissioned by the applicant and carried out by the appointed inspector. These serve the purpose of ensuring that the design requirements and specifications contained in the design documentation and the underlying standards and regulations on the production, transport, storage, installation, commissioning and operation of the structures are accordingly complied with.

In the run-up phase, a monitoring schedule must be agreed between the applicant, manufacturer(s) and the appointed inspector. During the design phase, a verified version of this plan shall be submitted to the approval authority prior to taking up production. This monitoring schedule must specify the components to be monitored and also include the scope of the spot checks. At all events, this plan must take account of all components and structural elements the failure of which could impair the structural integrity of the whole offshore structure (please refer to chapter B2.4.2.1).

The qualifications of the respective production facilities shall be examined prior to commencing production.

The monitoring schedule for the production facilities producing the main components is based on an initial audit to be carried out by the appointed inspector prior to commencing production. This shall also include an assessment of the production facilities with respect to their ability to achieve the required production quality.

The applicable standards and regulations as well as the verified implementation documents shall be given due consideration. The special requirements pertaining to "offshore" locations must receive due consideration with respect to all quality-securing measures.

Planning the implementation of the installation phase includes all loading, transport and installation procedures – from the quayside at the base port to the location at sea. The applicant is responsible for ensuring that the interfaces between those involved in designing the components are accordingly set up and maintained.

The installation phase (as understood in this standard) starts with the physical implementation of the wind farm, i.e. when the foundation elements and substructures are laid, and ends when operation commences.

The installation manual must be presented at the time of applying for the 3rd release (please refer to chapter B2.3.4). It must be submitted for the offshore structure as well as for the submarine cables at least 3 months prior to commencing work.

The applicant is the erector of the structure and thus bears full responsibility for the installation manual and ensuring that it is accordingly updated as implementation progresses, for conformity with the specified site-specific data and the implementation thereof, in particular with regard to the subsoil and the environment, the site-specific design and the test regulations right up to the point of actual installation.

The electrical connection of the subsea cabling within the park to the electrical infrastructure of the offshore wind turbine, resp. the connection of the power transmission submarine cable to the respective offshore substation, is no longer subject to the documentation contained in the installation manual.

The installation manual requires no further updates once the 3rd release has been awarded; once installation has commenced, all deviations and modifications must be documented as implementation progresses and accordingly agreed with the approval authority.

1.3.5 Operating phase

The operating phase includes the operation, maintenance and monitoring of offshore structures. During this phase, regular periodic inspections must be carried out. The appointed inspector shall issue the respective certificate of conformity in line with the test and inspection plan for periodic inspections.

Differentiations are made between two types of offshore structure inspections: Periodic and event-driven inspections. A periodic inspection specifically serves the purpose of examining any changes that become apparent with respect to the status of the support structure. An event-driven inspection must be conducted whenever damage is to be expected as a result of a specific event. If components and structural elements are subjected to a detailed inspection as the result of an event-driven inspection, the periodic inspections start afresh. The intervals specified for testing the various elements are merely guidelines. These must be adapted according to the location and type of offshore structure in question and must be accordingly noted in the test and inspection plan.

The operator shall submit the inspection reports resulting from the periodic inspections to the appointed inspector. The appointed inspector shall then assess the results of the periodic inspections with respect to the structural integrity of the overall structure and then compile a comprehensive report.

If the inspected offshore structures are operated correctly and in line with the regulations and regular inspections carried out (according to the test and inspection plan for periodic inspections) with respect to their structural integrity, the certificate of conformity for the test and inspection plan for periodic inspections shall be accordingly issued by the appointed inspector.

The verification report and certificate of conformity shall be submitted to the approval authority by the operator.

At the status meeting with the BSH, generally held once a year, the operator shall describe the technical status of the offshore structure. The approval authority may prescribe additional, suitable measures to ensure the offshore structure can be operated safely. Following this, the approval authority then decides whether the operating release is to be maintained or temporarily revoked.

Structural modifications to the systems must be documented in the as-built report once the work has been completed.

Analogous to the required verifications during the implementation phase, proof of safe transport from the production site to the installation location must also be supplied for all the main components and assemblies during the operating phase.

1.3.5.1 Documents to be made available for the periodic inspections

Different inspection intervals shall apply to the offshore structures due to the position of the parts to be inspected and their different qualities (e.g. design safety factors). Based on the test results, a request for deviation to modify the test intervals may be submitted after an appropriate period of time and frequent inspections. Exempt from the above are intervals that are subject to legal provisions or regulations.

The following areas must be included in each periodic inspection of an offshore structure as a minimum requirement.

- All load-bearing structural elements of an offshore structure that play an important and decisive role in stability against collapse
- Other supporting elements that play a decisive role in stability against collapse (e.g. structural bolts)
- Seabed composition
- Marine growth and
- Corrosion protection (coatings and anodes).

Which parts of the support structure actually need to be inspected, depends on the type of structure concerned. A differentiation needs to be made here, for example, between concrete and steel structures. In the test and inspection plan, only those parts of the structure relevant to the stability of the whole structure need to be taken into consideration.

With respect to the support structure, the following documents must be submitted to the appointed inspector:

- Test and inspection plan, as well as
- The reports on the most recently conducted inspections (monitoring reports).

With respect to equipment with an impact on the structural integrity of the support structure, the following documents must be submitted to the appointed inspector:

- Maintenance verifications
- Operations manuals of the technical systems to be inspected
- Technical documents and
- Reports on the most recently conducted inspections (monitoring reports).

All the test and inspection reports as well as the respective verifications must be archived and stored throughout the life cycle of the offshore structures.

1.3.6 Decommissioning phase

A decommissioning plan must be compiled in good time prior to the end of the operating phase, based on the decommissioning concept verified during the design evaluation process.

In as far as the state of the art has progressed between the design phase and the end of the operating phase, the decommissioning plan shall be modified to meet the current state of the art. The decommissioning plan agreed with the appointed inspector shall be submitted to the approval authority which reserves the right to carry out a plausibility check.

The realisation of the decommissioning plan is accompanied by detailed inspections and monitoring through the appointed inspector. The successful completion of the decommissioning phase is documented in a certificate of conformity which provides a summary of all the individual inspection reports and is submitted to the approval authority. The decommissioning phase is completed when the approval authority declares that the measure has been accordingly concluded.

2 Support structures

2.1 Preliminary remarks

With respect to the materials used (concrete, concrete reinforcing steel, prestressing steel, steel etc.), the general material parameters, in particular the strength and toughness values, shall be detailed. For the supporting components (primary and secondary structures), construction materials licensed in accordance with the List of Regulated Construction Products shall be used, in as far as no additional regulations have been included in the BSH Standard (e. g. choice of steel grade according to Appendix 5). If non-regulated products are used in exceptional cases (e. g. grout), an individual Technical Approval from the respective approval authority is required (please refer to Appendix 2). In this case, the BSH may appoint a suitable certified inspector to assess the component under consideration. The applicant shall communicate the usage of non-regulated construction products at an early stage.

In as far as new products or procedures are used alongside tried and tested corrosion protection systems in order to certify durability and the absence of pollutants – and in as far as these suitably represent the proper purpose –, their usage in offshore tests on auxiliary installations, such as measurement masts, shall be considered both appropriate and permissible with the aim of promoting the further development of such corrosion protection systems.

In the above case, the following procedure applies:
1. Presentation of a concept for carrying out the test by way of deviation from the codes of practice listed in chapter B2.3.1
2. Certificate confirming that the test has been accordingly conducted by a suitable institution (e. g. BAW), including an explanation detailing the approach used, the scope and the results of the test and, where appropriate, the requirements as a result of the test together with a
3. Opinion compiled by the appointed inspector.

The requirements pertaining to production monitoring mentioned in chapter B2.4.2.1 shall also apply to the foundation elements and the supporting components of the operational structure.

Different inspection intervals shall apply to the offshore support structures due to the position of the parts to be inspected and their different qualities (e. g. design safety factors) – please refer to Table 2-1. Based on the test and inspection results, a request for deviation to modify the test intervals may be submitted after an appropriate period of time and frequent inspections. Exempt from the above are intervals that are subject to legal provisions or regulations. The following areas at least shall be included in each periodic inspection of an offshore support structure:

- All load-bearing structural elements which are crucial for the stability against collapse
- Other supporting elements which are crucial for the stability against collapse (e. g. structural bolts)
- The seabed composition (e. g. scouring)
- Marine growth and
- Corrosion protection (coatings and anodes).

Which parts of the support structure need to be inspected depends on the type of structure concerned. A differentiation needs to be made here, for example, between concrete and steel structures. In the test and inspection plan only those components need to be taken into account that are of relevance to the stability of the support structure.

Corrosion protection is an important factor in obtaining approval, in particularly the following aspects:

- The technical aspect of corrosion protection that ensures that the verified stability and integrity of the structure remain intact for the expected technical life cycle of the structure
- The implementation of the safeguards shall be carried out with the lowest possible emissions so as to be accordingly environmentally-friendly and nature-compatible in order to protect the marine environment

Both the above are subject to tests and inspection by the authorities.

The various different strategies deployed by the builders of the structure with respect to corrosion protection shall be differentiated on the one hand according to the location (atmosphere, spray, water changes, underwater conditions) and, on the other hand, according to material characteristics, including the type of processing involved.
Possible strategies include, for example:

- Simple coating
- Coating in combination with a cathodic corrosion protection system (CCP)
- Impressed-current systems and/or
- Corrosion allowance, mostly in combination with the three processes described above.

In this connection, approvals based on corrosion protection systems (also on a combination of different systems), corrosion zones and suitability tests can be derived from the BAW lists detailed in chapter B2.3.1. The BAW lists are of a recommendatory nature. What is decisive is that the technical codes of practice are accordingly fulfilled.

With respect to the local areas of application, one must differentiate between the application of the respective corrosion protection system to the parts of the installation which are located above the water line, those in the water exchange zone and those which are under water.

When analysing materiality, as much attention to the chemical product shall be paid as to the treatment and processing of the specific components of the offshore structure.

2.1.1 Structural behaviour in the case of a collision of a ship with an offshore station

When assessing structural behaviour in the case of a collision of a ship with an offshore station, stability is of particular importance as both the safety of individuals and the security of supply must be upheld.

A collision analysis shall be conducted based on the information contained in Appendix 1. This shall include documentation stating which concept is planned with respect to a collision of a ship with the operational structure and its respective support structure. The following topics, for example, shall be discussed:

- The structure shall not fail and appropriate hull-retaining measures shall be accordingly documented.

At the same time, this analysis shall illustrate how the best possible hull-retaining design can be achieved.

2.2 Development phase

2.2.1 General

In order to inspect and assess the design basis to be submitted, the appointed inspector shall be involved by the applicant at the earliest possible stage prior to dimensioning, resp. preliminarily designing the installation structures.

2.2.2 Requirements and required verifications

2.2.2.1 Basic Prerequisites

The structural considerations involved in generating the draft design, as well as, in the case of an offshore station, the functional description (chapterB5.2.1), can be derived from an initial operation and safety concept resulting from the safety requirements and requirements to facilitate shipping and occupational safety (e.g. identifying and illuminating the installations, contingency plans).

2.2.2.2 Documents to be submitted when applying for the 1st release

[Doc. No. 210] Design basis, incl. the respective expert opinions

[Doc. No. 211] Verification report and certificate of conformity pertaining to Doc. No. 210

[Doc. No. 212] Preliminary design

[Doc. No. 213] Verification report and certificate of conformity pertaining to Doc. No. 212

With respect to the site conditions, the following minimal data shall be included in the design basis:

- Wind park layout, such as the location and configuration of the offshore structures, incl. the coordinates of all the offshore wind turbines, offshore stations and any other constructional components (please refer to chapter B1.3.2)
- Subsoil data (documents in accordance with chapter B3.2.3)
- Wind data
- Maritime conditions
  - Water depths
  - Water levels, wave data
  - Tides
  - Correlation of wind and waves
  - Ice drift
  - Currents
  - Scouring and morphodynamic changes of the seabed
  - Growth etc.

The design basis shall also include the following information:

- Definition of the loading conditions to be examined
- Definition of the standards and guidelines (incl. their respective hierarchy) to be used for calculating the structural design, materials etc., as well as
- The description of special verification methods where these are not based on the standards and guidelines.

With regard to corrosion protection, the following information shall be included in the design basis:

- Information on the codes of practice to be applied ("hierarchy of norms with respect to corrosion protection")
- Presentation of the planned corrosion protection systems, i.e. which types of corrosion protection are to be used for which components, including general information on their respective durability, as well as
- A note stating that this shall be further specified in the corrosion protection concept required for the 2nd release and on which the final design shall then be based.

Information on the further requirements pertaining to offshore stations is contained in chapter B5.2.3.

2.3 Design phase

2.3.1 Technical codes of practice

The support structures shall be designed in accordance with the Eurocode; in addition, the DIN standards in their respective latest white copy versions shall also apply. The BSH reserves the right to exclude individual standards or parts thereof from the obligation to apply the above standards.

The technical codes of practice listed below shall be applied in their respective latest version. The following list does not claim to be complete. When applying the design standards, the respective requirements for offshore structures, which differ from the standards commonly used in structural engineering, shall receive due consideration through the inclusion of appropriate codes of practice (please see below).

With regard to designing the steel components required to build the support structure of an offshore station, reference is herewith made to Appendix 5 (Application notes for the BSH Standard Design "Minimum requirements concerning the constructive design of offshore structures within the Exclusive Economic Zone (EEZ)").

Standards and guidelines for impact conditions:

DIN EN 1991	Actions on structures
DIN EN 1991-1-4	Actions on structures – Part 1-4: General actions – Wind actions (only concerns offshore stations)
DIN EN 61400-3	Wind turbines – Part 3: Design requirements for offshore wind turbines
API RP 2A-WSD	American Petroleum Institute, Recommended Practice – Planning, Designing, and Constructing Fixed Offshore Platforms-Working Stress Design
GL-IV-2	GL Rules and Guidelines, IV Industrial Services, Part 2 Guideline for the Certification of Offshore Wind Turbines
DNV-OS-J101	DNV Offshore Standard – Design of Offshore Wind Turbine Structures
GL-IV-7	GL Rules for the Certification and Construction, IV Industrial Services, Part 7 Offshore Substations
DNV-OS-J201	DNV Offshore Standard – Offshore Substations for Wind Farms
DNV-RP-C205	DNV Recommended Practice – Environmental Conditions and Environmental Loads

Design standards:

DIN EN 1993-1-1 to -1-10 + NA

DIN EN 1992-1-1 and -1-2 + NA

DIN EN 206-1 + Amendment A1 and Amendment A2

Standards and guidelines for the choice of material with respect to steel structures:

DIN EN 10025-1 to -4: Hot rolled products of structural steels, Parts 1-4; issue 11/2004, German version prEN 10025-1:2011

DIN EN 10225	Weldable structural steels for fixed offshore structures – Technical delivery conditions Note: With regard to the application of DIN EN 10225, reference is herewith made to Appendix 5 (Application notes for the BSH Standard Design "Minimum requirements concerning the constructive design of offshore structures within the Exclusive Economic Zone (EEC)"), Section 5-V. The application notes concerning the choice of steel grades set down in this section also apply to offshore wind turbines.
DIBt	DIBt guideline for wind turbines – Actions on and verification of stability against collapse for tower and foundation; October 2012, DIBt Berlin, German version.

Standards and guidelines for corrosion protection:

DIN EN ISO 12944	Paints and varnishes – Corrosion protection of steel structures by protective paint systems
DIN EN 61400-3	Wind turbines – Part 3: Design requirements for offshore wind turbines (IEC 61400-3:2009) German version EN 61400-3:2009; Annex H; alternatively: GL guideline or DNV standard
DIN EN 12495	Cathodic protection for fixed steel offshore structures
ISO 20340	Paints and varnishes – Performance requirements for protective paint systems for offshore and related structures
DIN EN 12473	General principles of cathodic protection in seawater; German version
DIN EN 12495 EN 12495	Cathodic protection for fixed steel offshore structures; German version
DIN EN 12496 (E) EN 12496	Galvanic anodes for cathodic protection in seawater; German version
BAW	List of approved systems II (for seawater and grounds, Im 2/3)
BAW	List of recommended coating systems for the corrosion protection of hydraulic steel structures
NORSOK M-501	Surface preparation and protective coating
NORSOK M-503	Cathodic protection
GL-IV-2	GL Rules and Guidelines, IV Industrial Services, Part 2 Guideline for the Certification of Offshore Wind Turbines
GL-IV-7	GL Rules and Guidelines, IV Industrial Services, Part 7 Offshore substations
DNV-OS-J101	DNV Offshore Standard – Design of Offshore Wind Turbine Structures
DNV-RP-B401	DNV Recommended Practice – Cathodic Protection Design

Notes:

- With regard to certifying the fatigue strength of reinforced concrete and prestressed concrete components, reference is herewith made to DASt publication 439 (Berlin 1994) “Fatigue Strength of Reinforced Concrete and Prestressed Concrete Components” and the explanations pertaining to verification in line with CEB-FIP Model Code 1990.
- With regard to the structural design of solid structures, reference is herewith made to the current version of the DNV-OS-C502 “Offshore concrete structures” guidelines.
- With regard to verifications using the finite element method, reference is herewith made to the GL Guideline for the Certification of Offshore Wind Turbines chapter 5.A “Strength Analysis with the Finite Element Method”.

2.3.2 Requirements and required verifications

The final design shall be verified by the appointed inspector through independent parallel calculations with respect to the structural integrity of the offshore structure. The results of this verification shall be represented in the verification report in a manner that is comprehensible and transparent.

The support structure shall be verified under due consideration of all the respective construction conditions, i. e. temporary conditions and conditions of limited duration during the erection and transport phases (incl. wave loads). Both the storage conditions and the material characteristics resulting from long and short-term loads shall be given due consideration for all the different static/dynamic systems concerned.

If such a construction state should last longer than six months, the respective rusting rate for the installation period shall be accordingly taken into account in the verification documentation. Alternatively, a temporary corrosion protection system may be implemented during the construction phase.

Taking the dynamic effects of the wind turbine into consideration:

- The influence line for calculating the support structure, incl. the foundation elements, shall be determined by calculating the overall dynamics.

  Proof shall be provided to confirm that the excitation frequencies of the installation and the natural frequencies of the support structure are suitably far apart. This shall be confirmed by calculations conducted using the following two equations:

  - $f_R / f_{0,1} \leq 0.95$
    where f_R = max. rotation frequency of the rotor during normal operation and
    where $f_{0,1}$ = first natural frequency of the support structure and
  - $f_{R.m} / f_{0,n} \leq 0.90$ resp. ≥ 1.05
    where $f_{R,m}$ = blade passing frequency of the m rotor blades and $f_{0.n}$ = n^{th} natural frequency of the support structure.

If it is planned to operate within the danger zone, vibration monitoring is required during operation.

Verification in the Ultimate Limit State – ULS:

- Strength verification
- Stability verification and
- Verifications pertaining to force application and connections.

Verifications in the Fatigue Limit State (FLS):

- During the verification control process, the special issues related to offshore structure fatigue shall be accordingly taken account of alongside the provisions contained in the respective rules of technology introduced by the construction authorities during the fatigue verification process. Suitable measures with respect to special boundary conditions such as implementation in seawater in the North or Baltic seas (please compare this with the corrosion regulations for offshore areas), free corrosion areas, or aspects connected with increased load change figures (please compare this with the DIBt guideline for wind turbines), shall be included in the draft.
- For amendments with respect to verifications in the fatigue limit state, please refer to Appendix 4 (for offshore wind turbines) and Appendix 5 (for offshore stations).

Verifications in the Serviceability Limit State – SLS:

- Limitation of deformation, possibly also accelerations,
- Limitation of concrete compressive stresses, concrete, resp. prestressed steel stresses and decompression and
- Limitation of concrete crack widths.

Verifications of durability:

- Verification of the corrosion protection concept:
  - Cathodic corrosion protection with sacrificial anodes in combination with coatings or by impressed-current systems and
  - Coatings
  - Allowance for rust in areas on which high demands are placed.

Verifications in the Accidental Limit State – ALS:

- In as far as such conditions exist.

Evaluation of hull-retaining properties of the support structure:

- Appropriate verification detailing the potential damage to a ship's hull on collision between an unmanoeuvrable ship and the support structure of an offshore wind turbine

Special points to be considered in connection with the verification of steel structures:

- The stability verification for circular cylindrical shells may be obtained by proceeding in accordance with the DIBt guideline "Wind turbines – Actions on and verification of stability against collapse for tower and foundation" (October 2012).
- Verification of the fatigue limit state for driven piles (also for monopiles) shall take account of the proportion of damage resulting from the actual pile-driving process.
- When designing the shear keys in a grouted joint connection, in particular, one should not ignore the possible overlap of bending moments with vertical force. Both the choice of materials and the verification of the design calculations are subject to an individual Technical Approval from the respective approval authority.
- Static verification of grouted joint connections may be obtained in accordance with the recommendations of GL or DNV using the finite element method and, if necessary, confirmed by laboratory tests conducted by an accredited test institute.

Special points to be considered in connection with the structural design of steel structures:

- The special corrosion risks connected with using stainless steel components shall be accordingly taken into account.
- The rotor/nacelle assembly and their respective equipment (non-load-bearing steel components (secondary steel), such as boat landings, platforms and ladders) shall be connected to the lightning protection and earthing system.

Special points to be considered in connection with the structural design of solid structures:

- Care shall be taken to route lightning protection and earth cables through the concrete structures for dissipation into the subsoil (e. g. connection to an existing reinforcement but on no account to a prestressed reinforcement).
- The special corrosion risks connected with using stainless steel components shall be accordingly taken into account.
- The structural design of reinforced concrete and prestressed concrete reinforcements shall take account of the aspects of minimum and crack reinforcement, rod and edge spacings, concrete covering, bending radii, anchoring and encroachment lengths, anchoring points for the transverse force reinforcement as well as corrosion protection measures for prestressed elements.
- In the case of a heavyweight foundation, a study on the required preparation of the seabed shall be provided at the 1st release stage. When compiling the EIA, the spacial delimitation (taking the ensuing slope angle into account) and the preparatory construction measures shall be described with such reliability that they can be used as a basis for the sediment management concept and sediment drift forecast.

Please refer to chapter B5.3.3 for more information on the requirements pertaining to offshore stations.

2.3.3 Documents to be submitted when applying for the 2nd release

[Doc. No. 220] Design basis – updated

[Doc. No. 221] Final design corrosion protection (please refer to Appendix 6)

[Doc. No. 222] Verification report and certificate of conformity pertaining to Docs. No. 220 and 221

[Doc. No. 223] Final design of the primary and secondary support structures

[Doc. No. 224] Verification report and certificate of conformity pertaining to Doc. No. 223

2.3.4 Installation manual

The approval holder is responsible for ensuring that an installation manual is compiled. The aim of this installation manual is to clearly illustrate all the processes involved together with their technical boundary conditions. The respective phases shall be described in sufficient detail so as to allow the appointed inspector to check the feasibility and logistics of the project.

The section covering the installation phase provides a comprehensive and transparent description of all steps involved in the implementation concept for installing the offshore structure from leaving the base port to arriving at the construction site.

The installation manual shall detail at least the following points in a plausible and transparent manner:

- Naming of all the major responsibility-bearers, together with their respective qualifications, incl. the Offshore Vehicle Coordinator (OVC),
- General list of permissions, i. e. document with details as to which persons/contractors are allowed to move around in the construction area, when and with which equipment
- Cooperation of all the persons, resp. contractors, in the construction area with the construction management
- Plan of the construction phases, incl. short descriptions
- How the construction area is to be secured
- Description of the transport and installation states
- In the case of a pile foundation, documentation detailing how the piles are to be installed (production report in accordance with DIN 12699 section 9.2)
- In the case of a heavyweight foundation, documentation on how the seabed is to be prepared (e. g. excavations)
- Description of the procedures pertaining to concrete (grout) connections and all other installation work linked with the foundation
- Description of any special work that needs to be done to install the foundation structure (e. g. pre and post-piling, ballasting procedures and ensuring the heavyweight foundation is correctly balanced)
- Description of the evidence confirming the purity of the seabed (incidental provision No. 13.6) and the proper disposal of waste and waste water generated by the construction site
- Drawing illustrating the accessibility of the installation site, the restricted areas and the protected zones.

2.3.5 Installation plan

A detailed plan of all the installation work involved shall be compiled prior to commencing work.

The installation plan for carrying out the work is the responsibility of the applicant and shall be compiled under observance of the legal provisions. The installation plan shall be based on the approach that danger to public safety or shipping must be ruled out.

Should specific instructions be provided by the manufacturer with regard to the transport or installation of individual components, these shall be accordingly adhered to. Any deviations from this ruling require the prior consent of the concerned parties.

Checklists and operation manuals shall be prepared and regularly updated with respect to all planned activities. A construction log shall be kept detailing all implementation steps. These documents shall be available for review at all times and shall be stored at suitable locations (a minimum of one copy in the construction management's marine office and one at the land base).

The installation plan shall be compiled under consideration of the equipment that is actually going to be used and the respective conditions, including but not limited to the following points:

- Project management
- Verification of the design documentation

- Verification pertaining to transport and transport safeguards
- Verification of the main components by means of drawings, specifications with regard to the installation procedure, load and weight information, including details on the centre of gravity, lashing points, and any special tools and procedures required
- Verification of how the components are to be handled during the installation procedure in compliance with the applicant's, resp. manufacturer's, instructions (e.g. accelerations during transport and installation, as well as the effect of waves, wind, temperature, precipitation, lightning etc.)
- Verification of the accessibility of the construction site (load-bearing capacity of the equipment, access routes, restricted areas and protection zones for shipping and aviation, access system for the structures)
- Verification of the major construction phases pertaining to transport and installation (e.g. construction phase plan, ancillary equipment and resources, arrangement of marine vessels, buoys, lights, ballasting, resp. balancing procedures, monitoring the condition of the seabed, required static and dynamic verification
- Verification of all the floating equipment involved in the operations on the basis of their classification (OM) or in the form of a special permit
- Verification of the dimensioning of the crane and lifting equipment, incl. all crossbeams, lashing cables, hooks and other ancillaries. All lifting equipment, cables and hooks shall be inspected on a regular basis with regard to the approved load. Where applicable, the crane manual shall be made available in accordance with the legal provisions.
- Marine coordination (OVC), regulation of the responsibilities and communication priorities for all major transport and installation procedures, provision of weather forecasts (weather reports from at least two independent weather services shall be obtained and made available)
- Verification of the towing and installation concepts, e.g. regarding the buoyancy of the structure (e.g. the substation platform), ensuring adequate buoyant force and a sufficient distance from the base of the body of water and
- Verification with respect to the purity of the seabed.

2.3.6 Documents to be submitted when applying for the 3rd release

[Doc. No. 230] Installation manual

[Doc. No. 231] Verification report pertaining to Doc. No. 230

[Doc. No. 232] Verification report pertaining to the installation plan

[Doc. No. 233] Decommissioning concept

[Doc. No. 234] Verification report pertaining to Doc. No. 233

[Doc. No. 235] Certificate of conformity

2.4 Implementation phase

2.4.1 Technical codes of practice

The following technical codes of practice, among others, in their respective current version, as well as the current state of the art, shall apply:

DIN EN ISO 19901-6 Petroleum and natural gas industries – Specific requirements for offshore structures, Part 6: Marine operations

DIN EN ISO 19905-1	Petroleum and natural gas industries – Site-specific assessment of mobile offshore units – Part 1: Jack-ups
ISO/DIS 29400	Ships and marine technology – Offshore wind energy – Port and marine operations
DIN EN 1990	Basis of structural design
DNV-OS-H101	DNV Offshore Standard – Marine Operations, General
GL-IV-7	GL Rules for the Certification and Construction, IV Industrial Services, Part 7 Offshore Substations
GL-IV-6	GL Rules for Classification and Construction, IV Industrial services, Part 6 Offshore Technology
API RP 2A-WSD	American Petroleum Institute, Recommended Practice – Planning, Designing, and Constructing Fixed Offshore Platforms – Working Stress Design
GL-IV-2	GL Rules and Guidelines, IV Industrial Services, Part 2 Guideline for the Certification of Offshore Wind Turbines
DNV-OS-J101	DNV Offshore Standard – Design of Offshore Wind Turbine Structures
DNV-OS-J201	DNV Offshore Standard – Offshore Substations for Wind Farms

Deviations from the German and international standards and guidelines listed above shall be submitted to the BSH for approval.

Should a machine be used outside its normal field of application for offshore activities, the suitability of this machine shall be verified and certified in accordance with the German Machine Ordinance.

The special codes of practice to be observed with respect to monitoring the production phase are listed in chapter B2.4.2 ff.

2.4.2 Requirements and required verifications

All equipment, procedures and materials used in offshore work shall comply with the German, resp. European standards, provisions and similar with respect to safety, environmental protection etc.

Where equipment, procedures or materials are used that are not in compliance with a recognised standard, appropriate approval shall be obtained from the approval authority. To this end, the approval authority may appoint a suitable expert to carry out this inspection, resp. recognise verifications provided by third party experts. Should a machine be used outside its normal field of application, the suitability of this machine shall be verified in accordance with the German Machine Ordinance.

Copies of the installation manual shall be available for review at all times – with a minimum of one copy in the construction management's marine office and one at the land base, as well as copies at all other locations deemed suitable.

The applicant shall provide evidence that an effective, certified management system in accordance with ISO 9001, Quality management systems – Requirements, is in place. Alternatively, should this certification not be currently available, the quality management system can be inspected on the basis of ISO 9001 by the appointed inspector.

A construction log shall be kept detailing all implementation steps. This shall be made available for review.

The approval holder is responsible for coordinating all the processes with the authorities, the companies carrying out the work and the appointed inspector.

2.4.2.1 Production monitoring

The activities of the appointed inspector incorporate monitoring activities with respect to verifying that the operational structure (topside) and the support structure have been manufactured in line with the approved implementation documents (e.g. drawings, calculations, specifications, verification reports) and meet the respective quality requirements. The monitoring of the production phase is conducted during the production process.

The monitoring of the production phase through the appointed inspector does not substitute quality monitoring or self-monitoring on the part of the respective component manufacturer. The scope of the spot checks to be carried out whilst monitoring the production phase is intended to provide a basic set of values for the respective project which allow the appointed inspector to confirm in a certificate of conformity that production has been carried out in compliance with the requirements once the production monitoring phase has been completed.

The monitoring services shall be carried out based on the agreed monitoring schedule. Initially, the scope of the spot checks to be carried out is understood to cover 20 % of all the components that impact health, safety, the environment, shipping and the structural integrity (stability and life cycle) specially manufactured for the project. When compiling the monitoring schedule, the special circumstances applying to mass-produced components shall be taken into account, if these cannot be allocated to a specific project during their production. This implies that identical components may also be used as an alternative basis for the conformity assessment procedure for a specific project. The scope of the spot checks and the methodology for extending or reducing the scope of these spot checks shall remain unaffected hereby.

Should no serious defects be established during the production of the first 20 % of the components to be monitored – and if there are no changes to the production process – a reduction of the scope of the spot checks to, for example, 10 % shall be coordinated with the appointed inspector (Figure 2-1). Prior to commencing production, the quantifiable criteria with a view to changing the scope of the spot checks shall be coordinated between the appointed inspector and the applicant, resp. approval holder. A serious defect is a defect that is expected to have an impact on health, safety, the environment, shipping or the structural integrity of the project. The respective producer is under obligation to notify the appointed inspector of any serious defects that may be established. In the case that a serious defect is established, the approval authority shall be notified of this defect immediately. In the case of a serious defect, the extent of the additional inspection work required as a result shall be agreed between the approval holder and the appointed inspector. In such cases, the scope of the spot checks may be increased to, for example, 75 % (Figure 2-2) – or in an extreme case – to 100 %. This shall be accordingly documented in the inspection report compiled by the appointed inspector in a comprehensible and transparent manner.

2.4.2.1.1 General requirements with respect to the monitoring of the production phase

In order to obtain an impression of the production company, the appointed inspector shall conduct an initial audit (of the production process) together with the client. This initial audit shall take place prior to commencing production. Should it be impossible at this point of time to audit the relevant production processes (e. g. because no comparable components are currently being produced), the audit may be carried out immediately after production has started – but only in exceptional cases and in coordination with the appointed inspector. The manufacturer shall submit all documents requested by the appointed inspector for inspection by the appointed inspector four weeks prior to the audit date as agreed in advance. In justified, individual cases, e. g. in the case of type certified installations or mass-produced parts which are produced in numbers far surpassing those required for the specific project in question, the appointed inspector may forego this initial audit and 20 % of the monitoring services planned to be carried out prior to the start of production. Any deviations established during this initial audit shall be alleviated prior to commencing production.

Other general documents that are to be presented within the scope of this inspection:

- Valid QM certificate in accordance with ISO 9001
- Quality management: QM manual, QM process and work instructions (project-specific, resp. product-specific, e. g. inspection plans, inspection instructions etc.)

2.4.2.1.2 Monitoring of the production phase (steel structures)

The following is a list of components to be monitored:

- Substructure
- Support structure
- Operational structure (topside).

With respect to steel structures, the following documents shall be submitted to the appointed inspector:

- Operating permit of the welding company, certificate of the welding company's suitability to weld steel structures in accordance with DIN 18800, Part 7, resp. DIN EN 1090

Operating permits that comply with other international standards (in as far as these are approved on a case-by-case basis by the appointed inspector through an individual examination)

- Qualification certificates and areas of responsibility of the supervisory welding staff (SWE or WS)
- Welding procedure tests in accordance with DIN EN ISO 15614 (Welding Procedure Quality Records – WPQR)
- Certificates for welding fillers
- Welding instructions in accordance with DIN EN ISO 15609 (Welding Procedure Specifications – WPS) and
- As-built drawings as provided
- Welding sequence schedule
- Corrosion protection specifications and
- Work instructions for activities requiring special monitoring (e. g. offshore welding)
- Test specifications, e. g. for non-destructive testing

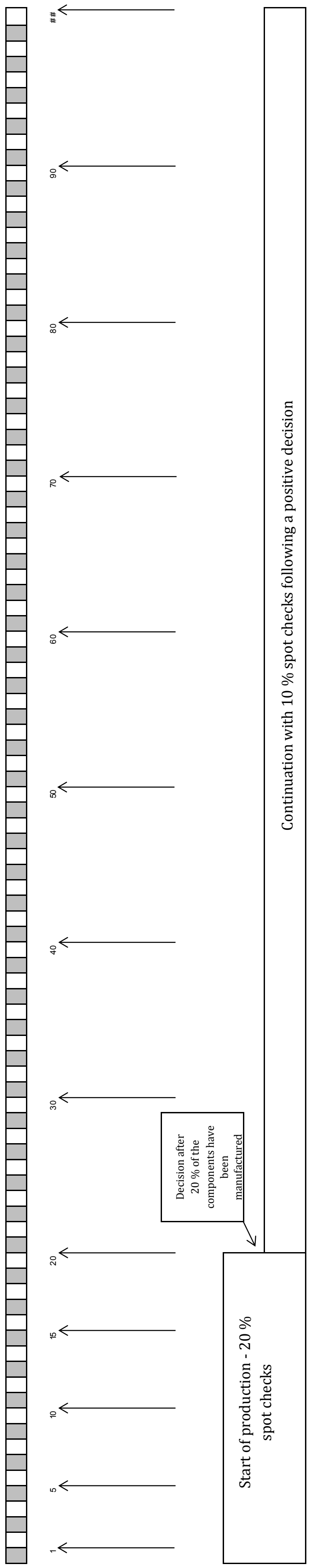


Figure 2-1: Illustration of the scope of spot checks where no defects are established (e.g. with a reduction to 10 %).

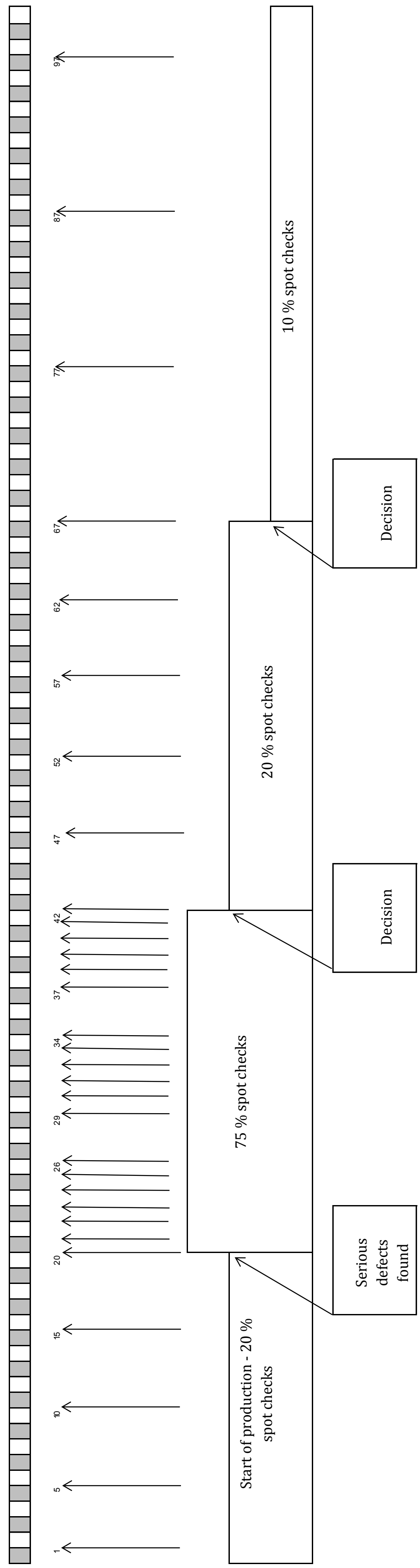


Figure 2-2: Illustration of the scope of spot checks in the case where serious defects are established (e.g. with an increase to 75 %).

Workshop planning and the welding procedure specifications shall be inspected with respect to their conformity with the implementation documents presented in the design review process.
The regular inspections to be carried out at the welding company during the production monitoring phase by the appointed inspector include the following checks:

- Inspection of the material certificates
- Consultation of the reports on the welding work carried out and the results of the non-destructive tests
- Inspection of the whole production process (products and processes, in particular the effectiveness of the QM system) and the implementation of the non-destructive tests, and
- Final inspection of the finished components:
  - Dimensions and tolerances
  - Corrosion protection implementation (e.g. preparation of the surface and coating thicknesses)
  - Visual check with respect to the general condition and possible damage
  - Transparency and traceability of the components and materials/semi-finished products used and
  - Inspection of the production documentation.

2.4.2.1.3 Monitoring of the production phase (concrete structures)

The following documents shall be submitted to the appointed inspector for both reinforced and unreinforced concrete components:

- Installation plans
- Formwork and reinforcement plans

The regular inspections to be carried out during the production phase by the appointed inspector are to be conducted based on the „Recommendations for the supervision of wind energy plants“ (BÜV) and in accordance with the valid standards:

- Inspection of the formwork with respect to
  - Limit dimensions, deflection of the plumb line
  - Formwork anchors
  - Tightness and cleanliness
  - Possible pre-treatment and
  - Release agents (enquiry to and instructions from the manufacturer).
- Inspection of the fixtures with respect to
  - Their position and how they are secured in place
  - Adverse effects on concrete compaction and
  - Reduced cross-section.
- Checking the reduced cross-section as a result of recesses and conduits.
- In the case of joints, checking the
  - Joint configuration (seals) and
  - Construction joints (roughness).

- In the case of reinforcements, checking the
  - Manufacturing and processing labels in accordance with DIN 488
  - Steel grade, diameter, shape, length and position
  - Anchorage lengths, encroachment lengths and mechanical connections
  - Links, stability and cleanliness
  - Spacers and supports (nominal and laying dimensions of the concrete cover)
  - Arrangement of concrete casting (rod spacing, concrete openings and vibrator gaps) and
  - Earthing.
- In the case of reinforcements, inspection of the
  - Approval for concrete reinforcing steel connections (observance of the boundary conditions) and
  - Certificate of suitability for welding concrete reinforcing steel in accordance with DIN EN ISO 17660.
- In the case of prestressed concrete, checking the
  - Position of the cladding tubes and how they are secured in place
  - Position of the mono-braids and how they are secured in place
  - Position of the anchorage and anchor bodies and
  - Anchor reinforcement.
- In the case of prestressed concrete, inspection of the
  - Approval for prestressing processes (observance of the boundary conditions and
  - Prestressing programme (prestressing order, partial prestressing, age of the concrete)
  - Work instructions (e. g. sealing against moisture, grouting using the cement mortar)
  - Prestressing logs
  - Grouting logs (report on the monitoring of the grouting work in accordance with DIN EN 13670 in combination with DIN 1045-3)
  - Construction log (tendon delivery and storage, corrosion protection, production – installation – grouting periods)
- In the case of concrete, checking the
  - Specification of the type of concrete
  - Maximum grain size and consistency
  - Casting sections and construction joints
  - Identification and marking of the construction site (in accordance with DIN EN 13670 in connection with DIN 1045-3) and the monitoring body
- In the case of concrete, inspection of the
  - Work instructions with respect to processing the surfaces and their respective post-treatment
  - Casting concept
  - Work instructions with respect to post-treatment and the
  - Report of an independent monitoring body (DIN 1045-3).

- In the case of concrete components, checking the following after production and prior to commissioning
  - The age of the concrete, resp. its consistency prior to subjecting it to loads (possibly including a hardening test)
  - Surface
  - Cracks
  - Desiccation
  - Joints (e.g. construction joints, grouted joints, material transitions) and
  - Fixtures.
- In the case of concrete components, inspection of the following after production and prior to commissioning
  - Recorded information and concrete delivery notes and
  - Levelling log.
- In the case of precast concrete components, a respective check at the prefabrication plant.
- In the case of precast concrete components, inspection of the
  - Labelling and delivery notes
  - Monitoring reports of the recognised monitoring body
  - Certificate of compliance and
  - Verifications with respect to special manufacturing processes (e.g. spun concrete).
- When installing precast concrete components, checking the
  - Lifting anchors
  - Limiting dimensions (components and connectors)
  - Storage and
  - Possible transport and installation damage.
- When installing precast concrete components, inspection of the installation instructions.

2.4.2.1.4 Monitoring of the production phase (grouting)

With respect to grouting, the requirements set down in the individual Technical Approval (Appendix 2) shall be observed. The on-site monitoring measures for a construction site classified as a monitoring class 3 site in accordance with DIN 1045-3, as well as any other additional monitoring measures required as a result of the individual Technical Approval, shall be carried out, resp. commissioned, by the contractor. The specialist assessment shall be conducted by the assessor engaged by the approval holder. The results of one‘s own and any third party monitoring measures shall be submitted to the appointed inspector.

2.4.2.1.5 Monitoring of the production phase (cast components of the support structure)

The cast components to be monitored include all cast components that have an impact on the stability of the installation (e.g. cast nodes).
With respect to cast components, the following documents shall be submitted to the appointed inspector:

- Component specifications
- Drawing of the raw casting

- Machining drawing
- Test drawing
- Drawing of the surface treatment
- Post-treatment specifications

The regular inspections to be carried out by the appointed inspector during the production monitoring phase at the foundry and the sub-suppliers of the respective components include the following checks:

- Inspection of the whole production process (product and process) and the carrying out of non-destructive testing
- Casting date, removal date, removal temperature
- Chemical composition, as-cast microstructure, mechanical properties
- Sampling concept (stamping)
- Requirements of the NDT tests, test personnel
- Geometric requirements (wall thicknesses, fits, bores etc.)
- Thickness of the corrosion protection layer
- Inspection of any other quality information recorded and outgoing goods examinations
- Transport concept and storage.

2.4.2.2 Monitoring of the commissioning phase

Commissioning follows installation and grid connection. Prior to commencing monitoring activities, a commissioning manual shall be compiled and submitted to the appointed inspector for examination. The monitoring of the commissioning phase incorporates checking the following:

- Conformity of the main components of the support structure with the verified design documentation and their respective traceability and numbering
- Checking the first natural frequency of the overall installation on-site (offshore)
- Requirements from the verification reports
- Functional tests and tests of the safety system
- Corrosion protection and
- Damage.

The appointed inspector shall be involved in the commissioning of at least two offshore wind turbines (for each type of construction) and the respective offshore stations. The appointed inspector shall determine which installations are to be reviewed. It is not necessary for the appointed inspected to be present for the whole duration of the commissioning of the installations and offshore stations. The most important parts of the commissioning phase to be inspected in the presence of the appointed inspector shall be agreed in advance between the approval holder and the appointed inspector. Where phases of the commissioning process have already been carried out for the first offshore wind turbine without any serious problems, only spot checks are needed for the second installation.

Once the monitoring of the commissioning phase has been successfully completed, a respective verification report shall be compiled.

2.4.2.3 As-built report

Once the installation phase has been completed, the as-built status shall be accordingly documented. This shall include a representation summarising all the major deviations from the approved documentation that have an effect on the structural integrity of the overall structure, incl. geometric deviations (site, incline, tolerances, shock), structural deviations (e. g. additional intermediate elements), deviations in production, grouting etc.

2.4.3 Documents to be submitted when applying for operating release

The following documents shall be included with the documentation for applying for operating release:

[Doc. No. 240] Inspection reports and certificate of conformity pertaining to

- The monitoring of the production phase
- The monitoring of transport and the installation phase as well as
- The monitoring of the commissioning phase.

[Doc. No. 241] Corrosion protection – verification confirming that implementation (application) has been carried out properly and that the quality of the processing corresponds to the requirements

Verification may be performed based on acceptance procedures according to DIN EN ISO 12944-8, incl. the Appendix thereto (form), resp. in accordance with the respective Additional Technical terms of Contract (ZTV).

[Doc. No. 242] Verification report of the appointed inspector pertaining to Doc. No. 241, based on the verification reports supplied by the approval holder in accordance with DIN 10204

[Doc. No. 243] As-built report

[Doc. No. 244] Verification report pertaining to Doc. No. 243

[Doc. No. 245] Operations manual

This document shall contain a description of at least the following points in a plausible and transparent manner:

- General sequence of operations
- Communication flows
- Monitoring of the offshore wind farm
- Monitoring of the offshore station for the substation as well as the grid connection within the farm
- Monitoring of the offshore converter station and the power export cable
- Maintenance and repair concepts.

[Doc. No. 246] Verification report pertaining to Doc. No. 245

When operation commences, the appointed inspector shall make sure that the content of the operations manual is correct and that all processes are being carried out correctly. This shall be accordingly documented in the verification report.

[Doc. No. 247] Concept for the periodic inspections, incl. test and inspection plan

The concept for the periodic inspections, incl. the test and inspection plan shall be submitted no later than 3 months following the trial operation of the first wind turbine or offshore station. This document shall contain a description of at least the following points in a plausible and transparent manner:

- Planned inspection intervals and the respective explanatory statement
- Identification of the parts subject to wear, in particular the parts that are subject to special demands and stress due to marine influences (e.g. corrosion and marine growth)
- Determining of the scope of the inspections and the inspection intervals depending on the durability and environmental compatibility of the respective corrosion protection system, as well as
- Monitoring of the scouring protection system.

[Doc. No. 248] Verification report pertaining to Doc. No. 247

[Doc. No. 249] Project certificate

2.5 Operating phase

2.5.1 Preliminary remarks

Operations shall begin on the date of issue of the operating release by the BSH; this presupposes that the incidental provisions of the notice of approval have been accordingly fulfilled and likewise presumes that all stipulations made at the various approval stages have been fulfilled during the preceding phases. On a case-by-case basis, non-significant tasks that remain to be completed may be carried out during the operating phase if so agreed with the approval authority. This shall be noted in the operating release document. The operating release is based on establishing that the structures have been installed correctly.

During the operating phase, a status meeting between the approval holder and the approval authority shall be held once a year in order to discuss the condition of the offshore wind farm. To this purpose, the approval holder shall compile a detailed and informative status report on the condition of the offshore structures. This shall be submitted to the approval authority at least six weeks prior to the scheduled meeting, together with the summary verification report compiled by the appointed inspector, as well as the certificate of conformity pertaining to the test and inspection plan for periodic inspections (please refer to chapter B1.3.5).

In the case of changes to the morphological structure of the terrain in question (e.g. scouring) in excess of that provided for in the provisions upon which the structure is based, a new statement on the stability shall be drawn up, whereby a geotechnical planning expert shall be accordingly involved.

In the case of major repair work or component replacement, the procedure to be followed shall be based on the conditions for installing the structure; the appointed inspector shall be accordingly involved in this process. This process is completed by the submission of a respective report to the BSH by the approval holder.

The operating release marks the commencement of normal operations following the installation of the structure.

2.5.2 Technical codes of practice

The following technical codes of practice, among others, in their respective current version, as well as the current state of the art, shall apply analogous to the installation procedure:

DIN EN ISO 19901-6	Petroleum and natural gas industries – Specific requirements for offshore structures, Part 6: Marine operations
DIN EN 1990	Eurocode 0: Basis of structural design
DNV-OS-H101	DNV Offshore Standard – Marine Operations, General
GL-IV-6	GL Rules for Classification and Construction, IV Industrial services, Part 6 Offshore Technology
API RP 2A-WSD	American Petroleum Institute, Recommended Practice – Planning, Designing, and Constructing Fixed Offshore Platforms – Working Stress Design
GL-IV-2	GL Rules and Guidelines, IV Industrial Services, Part 2 Guideline for the Certification of Offshore Wind Turbines
ISO/DIS 29400	Ships and marine technology – Offshore wind energy – Port and marine operations

Should a machine be used outside its normal field of application, the suitability of this machine shall be verified and certified in accordance with the German Machine Ordinance.

Deviations from the German and international standards and guidelines listed above shall be submitted to the BSH for approval.

2.5.3 Requirements and required verifications

During the operation of offshore structures, the approval holder shall ensure the integrity of the structure and that the installation has the lowest possible impact on the environment. In order to guarantee this, the structures and their components shall be subjected to recurring inspections and examinations at event-orientated intervals during the whole life cycle of the structure. These inspections shall be carried out by an independent third party in accordance with the test and inspection plan and within the scope of the concept for conducting periodic inspections (please refer to chapters B1.3.5, B4.5 and B5.5.3).

Which parts of the support structure need to be inspected depends on the type of structure concerned. A differentiation needs to be made here, for example, between concrete and steel structures.

For the periodic inspections, an object-specific and site-specific checklist (test and inspection plan) shall be compiled based on the technical documentation. This shall contain object and site-specific assessment criteria. The test and inspection plan shall primarily include those parts of the structure relevant to the stability of the whole structure.

The minimum requirements pertaining to the periodic inspections of the support structures are listed in Table 2-1.

When compiling the inspection plan, components that have a negative effect on humans and/or the environment in the event of a failure (e. g.: outer rail, platforms, grids, ladders, collecting basins for environmentally hazardous substances) should also be given due consideration alongside those support structures listed in Table 2-1.

Test object	Test basis and intervals
Test object	Test basis and intervals
Functionality of the anodes, impressed-current system	During the first 2 years: annually, then depending on the condition (recommended every 4 years)
Substructure: Welded seams (subject to cyclic loads), intactness of the surface of the structural elements	In accordance with the life cycle calculations and the inspection plan
Composition of the seabed surface, scouring	During the first 2 years: annually, then depending on the condition (recommended every 4 years)
Corrosion protection (visual inspection): • Underwater area of the structure • Alternating load • Underwater area of the substructure • Operational structure (support structure)	Depending on the condition (recommended every 4 years) Depending on the condition (recommended every 2 years) Depending on the condition (recommended every 4 years) Depending on the condition (recommended every 4 years)
Operational structure: Welded seams (subject to cyclic loads), support structure bolts	In accordance with the life cycle calculations and inspection plan

Table 2-1: Minimum requirements with regard to the periodic inspections of support structures

The appointed inspector shall compile a summary verification report of all the examinations carried out in accordance with the test and inspection plan and on an annual basis. This report shall contain details on all the tests and inspections carried out in the form of an overview which includes the due dates and the respective results. The BSH reserves the right to demand the submission of additional monitoring and inspection reports and verifications should a test and inspection plan be found to be inadequate or missing. Reference is made herewith to other directives that may be applied in accordance with SeeAnlV. This shall apply, in particular, to cases representing a danger to either structural or operational safety.

The verification report shall be submitted by the approval holder to the approval authority, together with the status report (please refer to chapter B2.5.1) and the certificate of conformity (please refer to chapter B1.3.5).

2.5.4 Documents to be submitted

Within the scope of the periodic inspections, the following minimum documents shall be presented:

[Doc. No. 250] Annual summary verification report of the appointed inspector (monitoring report – summary of the results of the periodic inspections, please refer to chapters B1.3.5 and B2.5.3).

With respect to the operation, all modifications resulting from ongoing operations shall be documented in the operations manual. The operations manual shall be accordingly updated. Geotechnical documents in accordance with B3.5.4 and a statement on the stability in the case of a change to the morphological structure compiled in association with a geotechnical planning expert may also need to be submitted.

[Doc. No. 251] Confirmation of the appointed inspector in the case of repair work or component replacement

This document shall contain a plausible and transparent description of the inspection that includes at least the following points:

– Verification pertaining to transport procedures (towing procedures etc.) and repair work, as well as

– Verification pertaining to the transport and installation states

With respect to the operation, all modifications resulting from ongoing operations shall be documented in the operations manual which shall be accordingly updated.

[Doc. No. 252] Annual certificate of conformity confirming that tests and inspections have been carried out in accordance with Doc. No. 250 and in compliance with the test and inspection plan for periodic inspections.

2.6 Decommissioning phase

2.6.1 Preliminary remarks

When operations cease, the offshore structures are generally to be decommissioned. This requires a detailed plan to be drawn up and a verified version presented to the BSH for approval.

The approval holder is responsible for compiling a decommissioning instruction manual. The objective of the decommissioning instruction manual is to provide a plausible representation of all the processes involved and the respective technical boundary conditions.

The detailed final design for carrying out the decommissioning work is the responsibility of the approval holder in cooperation with the respective contractor and shall take due consideration of the legal provisions and be accordingly inspected by the appointed inspector. This plan shall be compiled under consideration of the equipment that is actually going to be used and the respective conditions, including but not limited to the following points:

- Project management
- Verification of the design documentation
- Verification pertaining to transport and transport safeguards
- OVC (Offshore Vehicle Coordinator)
- Verification of the disassembly concept, e.g. regarding the buoyancy of the structure (e.g. the operational structure (topside)), ensuring adequate buoyant force and a sufficient distance from the base of the body of water
- Verification of the components is achieved through a visual examination and includes, among others, material verifications, correct disassembly conditions, anchor devices, disposal verifications and
- Risk analyses.

For the decommissioning phase, all the major components and installations, resp. disassembled parts, shall be accordingly represented – from the decommissioning location to being transported to the port – in order to minimise the risks. The verifications are analogous to those required during installation.

The decommissioning instruction manual does not need to be updated; changes shall be documented and coordinated with the approval authority.

2.6.2 Technical codes of practice

The following technical codes of practice, among others, in their respective current version, as well as the current state of the art, shall apply:

DIN EN ISO 19901-6	Petroleum and natural gas industries – Specific requirements for offshore structures – Part 6: Marine operations
DNV-OS-H101	DNV Offshore Standard, Marine Operation, General
GL-IV-6	GL Rules for Classification and Construction, IV Industrial services, Part 6 Offshore Technology
API RP 2A-WSD	American Petroleum Institute, Recommended Practice – Planning, Designing, and Constructing Fixed Offshore Platforms – Working Stress Design
GL-IV-2	GL Rules and Guidelines, IV Industrial Services, Part 2 Guideline for the Certification of Offshore Wind Turbines
DNV-OS-J101	DNV Offshore Standard – Design of Offshore Wind Turbine Structures
DIN EN 1990	Basis of structural design
ISO/DIS 29400	Ships and marine technology – Offshore wind energy – Port and marine operations

Should a device or equipment be used outside its normal field of application for offshore activities, the suitability of this equipment shall be verified in accordance with the German Machine Ordinance.

In the case of deviations from the standards and codes of practice listed above, an application for approval shall be submitted to the BSH.

2.6.3 Requirements and required verifications

All equipment, procedures and materials used in offshore work shall comply with the German and European standards, provisions and similar with respect to safety, environmental protection etc.

Where equipment, procedures or materials are used that are not in compliance with a recognised standard, appropriate approval shall be obtained from the BSH. To this end, the BSH may appoint a suitable expert to carry out this inspection, resp. recognise verifications provided by third party experts. Should a machine be used outside its normal field of application, the suitability of this machine shall be examined in accordance with the German Machine Ordinance.

Copies of the decommissioning instruction manual shall be available for review at all times at suitable locations – at least in the construction management's marine office and at the land base.

With respect to decommissioning work, the logistics for all the major components and disassembled parts from the installation site to the base port shall be accordingly represented and verified so as to eliminate danger to individuals, equipment and the environment as far as possible.

During implementation, a decommissioning log shall be kept. This shall be made available for review.
The applicant is responsible for coordinating all the processes with the authorities, the companies carrying out the work and the appointed inspector.

2.6.4 Documents to be submitted when applying for decommissioning release

[Doc. No. 260] Decommissioning instruction manual

- This document shall contain a description of at least the following points in a plausible and transparent manner:
- Decommissioning phase plan, incl. a short description of the most important work to be carried out
- Information on how the decommissioning zone is to be secured
- Description of the transport and disassembly conditions
- Description of the evidence confirming the purity of the seabed (incidental provision No. 13.6) and the proper disposal of waste and waste water generated by the construction site.

[Doc. No. 261] Verification report pertaining to Doc. No. 260

[Doc. No. 262] Certificate of conformity pertaining to the decommissioning plan

[Doc. No. 263] Verification of the decommissioning depth to be obtained through suitable measuring procedures or a comparative assessment of the work logs, resp. daily reports

[Doc. No. 264] Confirmation of the appointed inspector with regard to the decommissioning work

This document shall contain a plausible and transparent description of the inspection that includes at least the following points:

- Verification of the design documentation
- Verification pertaining to the disassembly and transport concept
- Verification pertaining to the towing procedures
- The decommissioned components and accessories shall be classified according to the current state of the art at this point in time
- Material certificates, disassembly conditions, anchor devices etc.
- Disposal verifications covering all stages until reaching the quayside
- Verification pertaining to the decommissioning depth.

2.6.5 Documents to be submitted in order to close the decommissioning phase

[Doc. No. 270] Final as-built report

The final as-built report shall document the final status of the decommissioning work and shall serve to pass on the data so that it may be accordingly added to the nautical charts once the operating life of the installation has come to an end.

[Doc. No. 271] Inspection reports and certificate of conformity following the completion of the decommissioning work

3 Foundation elements

3.1 Preliminary remarks

The basic definitions pertaining to the geotechnical systems resulting from the subsoil and the foundation elements are derived from DIN EN 1997 (EC 7) and the references contained herein.

The following geotechnical documents are required for submitting an application to the BSH:

(1) In accordance with the Standard Ground Investigations:

- Preliminary ground investigation report
- Main subsoil inspection report
- Subsoil and foundations survey (development phase) and
- Subsoil and foundations survey (design phase)

(2) In accordance with this Standard Design:

- Geotechnical design report, where necessary, including a supplementary expert opinion on cyclic loads (“cyclics”)
- Geotechnical as-built documentation (geotechnical installation report) and
- Supplementary geotechnical reports.

The subsoil and foundations survey (design phase) contains proposals which allow for cyclic loads when calculating the foundation elements (“cyclical concept”). The geotechnical design report may also incorporate a supplementary expert opinion which includes the results of laboratory tests aligned to the specific design in question to investigate the ground properties under cycle load application (supplementary expert opinion on the “cyclics”).

The documents listed in (1) above constitute the basic planning documents. These shall be compiled by a geotechnical expert in accordance with the BSH Standard Ground Investigations. The documents listed in (2) above constitute the geotechnical planning contribution to the design of the foundation elements. These shall be developed by a planning expert for geotechnics on behalf of the architect. The geotechnical design report shall include the basic planning documentation by way of reference to the ground investigation report and the subsoil and foundations survey (design phase).

Table 3-1 illustrates the most important content and the authors responsible for this content, as well as the descriptions of the reports in both of the BSH standards quoted above and the corresponding reports in the respective normative standards with a view to providing precise information for the BSH application procedure.

<table>
<tr><th rowspan="2">Core content</th><th colspan="4">Descriptions according to</th></tr>
<tr><th colspan="2">BSH Standards (2014 and later)</th><th>DIN</th><th>EC-7</th></tr>
<tr><td>Geotechnical investigation report</td><td>GTE*</td><td>Preliminary ground investigation report Main ground investigation report</td><td rowspan="2">Geotechnical report (DIN 4020)</td><td rowspan="3">Geotechnical design report
(DIN EN 1997-1 and DIN 1054, 2011 and later)</td></tr>
<tr><td>Characteristic parameters, subsoil model and foundation proposal</td><td>GTE*</td><td>Subsoil and foundations survey (development phase) Subsoil and foundations survey (design phase)</td></tr>
<tr><td>Stability and serviceability verifications</td><td>PEG (arch.)**</td><td>Geotechnical design report, (where necessary, including a supplementary expert opinion on the “cyclics”)</td><td>Geotechnical design report (DIN 1054 until 2010)</td></tr>
</table>

* GTE: Geotechnics expert
** PEG (arch.): Planning expert for geotechnics on behalf of the architect

Table 3-1: Content, descriptions of and responsibilities for the documents in accordance with the Standards Ground Investigations and Design and comparison with the corresponding descriptions in the respective normative standards.

The exact definition and separation of the areas of responsibility to be covered by the geotechnics expert and the planning expert for geotechnics are the responsibility of the applicant.

Note:
According to DIN EN 1997-1, 2.8, A Note to (3), both the geotechnical report and the geotechnical design report may be compiled by the same person/organisation, if this person/organisation has acquired the necessary expertise and experience.

From a geotechnical viewpoint, offshore structures are extremely complex structures, the foundations of which are classified as belonging to geotechnical class 3 (GK 3) in accordance with DIN 1054 (earthwork and foundation engineering and geotechnical measures with a high geotechnical risk). They require their foundation design to be conducted by a planning expert for geotechnics (a geotechnical expert with thorough knowledge of and experience in this area). Where necessary, the applicant, resp. approval holder, shall define the tasks to be carried out by the planning expert for geotechnics and those to be carried out by the geotechnics expert in accordance with the Standard Ground Investigations, Part A, Section 4.

Beyond the uncertainties of the local subsoil situation, it is also necessary to consider the limited possibilities of deterministic calculation models in geotechnology when designing the foundation elements of offshore structures.

The achievable “accuracy” of numerical model calculations including the subsoil is significantly lower than that of design components due to the implementation of what are, by necessity, highly simplified stress deformation relationships and contact surface conditions. As a rule, therefore, variations of the significant geotechnical influencing parameters shall be undertaken by means of which their influence on the draft target is limited and which indicate how the overall structure will “behave” within these limits to a sufficient degree of probability (Appendix 3-V).

This procedure is essential for all verifications in which subsoil deformations are contained as a target or influencing parameter, in which changes in the subsoil properties have to be considered, and in which assumptions are made regarding model parameters due to the lack of determinability.

To the extent that subsoil deformations are relevant in terms of the design but cannot be predicted with the necessary level of accuracy, the resulting problems shall be bypassed using suitable design measures if circumstances permit. Otherwise, the observation method in accordance with DIN EN 1997 (EC 7) shall be applied (Appendix 3-IV).

Where cyclic loads are applied to an offshore structure, one can expect the load-bearing behaviour of the foundation to differ considerably from that of static and variable loads. Currently, there are no generally accepted or suitably validated calculation models for designing foundation elements which are subject to cyclic loads. Accordingly, the codes of practice set down in this standard do not currently contain any standard regulations in this respect. With respect to the application of the codes of practice set down in this standard to offshore wind turbines in the EEZ, the scope for action with regard to planning and testing within the current application process is specified in the application notes contained in the Appendices 3-I.2, 3-I.3, 3-I.4 and 3-II.

3.2 Development phase

3.2.1 Technical codes of practice

The technical codes of practice to be applied are detailed in section B3.3.1.

3.2.2 Requirements and required verifications

The requirements pertaining to the geotechnical documents and required verifications during the development phase are regulated in the Standard Ground Investigations.

3.2.3 Documents to be submitted for the 1st release

The documents required to obtain the 1st release shall be supplemented by the following verified geotechnical documents in accordance with the BSH Standard Ground Investigations:

[Doc. No. 310] Geological report,

[Doc. No. 311] Preliminary ground investigation report

[Doc. No. 312] Subsoil and foundations survey (development phase)

[Doc. No. 313] Verification report pertaining to Docs. No. 310, 311 and 312.

3.3 Design phase

3.3.1 Technical codes of practice

3.3.1.1 Hierarchy of codes

The foundation elements shall be designed in accordance with Eurocode 7; in addition, the DIN standards in their respective latest white copy versions shall also apply. The BSH reserves the right to exclude individual standards or parts thereof from the obligation to apply the above standards.

In addition, the following provisions of this standard shall apply:

Appendix 3-I	Consideration of cyclic loads in the design of foundation elements
Appendix 3-II	Verification of the limit states for foundation elements taking into account cyclic loading
Appendix 3-III	Dynamic pile load tests

Appendix 3-IV	Use of the observation method according to Eurocode 7
Appendix 3-V	Application of numerical models for geotechnical verifications.

Other codes of practice may be applied according to the rules pertaining to deviations and amendments set down in chapter A3.

Where required, transitional arrangements shall be agreed with the BSH on a case-by-case basis.

3.3.1.2 Codes of practice for loads

The national DIN standards and codes of practice do not cover, resp. do not completely cover all loads to which offshore structures are subjected. As a result, additional codes of practice shall be referred to accordingly. With respect to loads, reference is herewith made to the following standards and guidelines which can be used by the architect as a basis for determining the loads on the foundation elements:

DIN EN 61400-3	Design requirements for offshore wind turbines
DIN 1055-4	Actions on structures – Part 4: Wind loads
DIN EN 1991-1-4	Actions on structures – Parts 1–4: General actions – Wind loads
API RP 2A-WSD	American Petroleum Institute, Recommended Practice – Planning, Designing, and Constructing Fixed Offshore Platforms – Working Stress Design
GL-IV-2	GL Rules and Guidelines, IV Industrial Services, Part 2 Guideline for the Certification of Offshore Wind t´Turbines
DNV-OS-J101	DNV Offshore Standard – Design of Offshore Wind Turbine Structures

Further details with regard to determining cyclic loads are set down in Appendix 3-I.

3.3.1.3 Codes of practice for dimensioning and implementation

The architect and the planning expert for geotechnics shall apply the following basis standards and their respective amendments and normative references, incl. the associated implementation standards:

Geotechnics

DIN EN 1997-1	Eurocode 7: Geotechnical design, Part 1: General rules
DIN EN 1997-1/NA	National Annex – Nationally determined parameters, Eurocode 7: Geotechnical design, Part 1: General rules
Eurocode 7	Geotechnical design – General rules
DIN 1054	Subsoil – Verification of the safety of earthworks and foundations – Supplementary rules to DIN EN 1997-1. German version

Steel construction

DIN EN 1993-1-1 to -1-10	
DIN EN 1993-1-1 to -1-10/NA	National Annex (Eurocode 3)

Reinforced concrete construction
DIN EN 1992-1-1

DIN EN 1992-1-1/NA National Annex (Eurocode 2)

Concrete
DIN EN 206-01 and Amendments 1 and 2

Further details with regard to considering cyclic loads on the foundation elements are regulated in
Appendix 3-II Verifications in the limit states of the foundation elements under consideration of cyclic loads.

3.3.2 Requirements and required verifications

3.3.2.1 Safety verification concept and procedures, level of stability against collapse

The geotechnical verifications pertaining to the stability of the subsoil, the foundation elements and their components shall be issued in accordance with the following principles:

- The mechanisms of the expected interaction between the subsoil and the structure shall be represented and considered in the verifications for the foundation elements.
- In all cases, a verification concept with characteristic subsoil parameters and partial safety factors on the load side and the resistance side (load and resistance factors) shall be used (GEO-2 verification process in accordance with DIN EN 1997). Deviations are permitted in justified cases (GEO-3 verification process in accordance with DIN EN 1997 or similar), in particular in cases where the interaction between the subsoil and the structure does not permit definitive separation between load and resistance or if the resistances are directly or indirectly dependent on external effects (e. g. shearing resistances of external loads). In such cases, a comparable level of stability against collapse shall be demonstrated.
- The concept used to take account of the effects of cyclic loads shall be accordingly represented in the verifications.
- The applicability of the verification process used shall be documented. Violations of the documented application limits shall be evaluated and documented.
- To the extent that recognised verification processes are unavailable and a separate calculation model with calculation processes is designed, the model and the calculation process shall be presented in a way that permits it to be tested and be comprehensively documented. If the calculation results achieved through this method are not without doubt and no major safety reserves in the structure are indicated for the problem being dealt with, then the applicability of the model, the process itself and its assumptions in the application case shall be verified by a suitable measurement and observation programme on the structure. These measurements and observations form a necessary component of the verification and shall be presented as such together with the verification; this process corresponds to the "observation method" in accordance with DIN EN 1997 (EC 7), its elements shall be implemented in full (please refer to Appendix 3-IV).
- Deviations from the level of stability against collapse in accordance with DIN 1054 are basically permitted for considering the special conditions of the offshore situation; any such deviations shall be indicated and justified. Lower deviations from this level of stability against collapse shall require the approval of the BSH which may engage the services of a suitable assessor for this purpose. If different safety concepts and verification processes are used, equivalence of the safety statement shall be confirmed by an expert.

3.3.2.2 Material designations and parameters

The material parameters used for the subsoil types shall be determined and designated according to the relevant DIN standards. Deviating or supplementary processes and designations shall be indicated as such and comprehensively documented.

3.3.2.3 Subsoil model and characteristic subsoil parameters

The current version of the "Standard Ground Investigations – Minimum requirements for geotechnical surveys and investigations into offshore wind energy structures, offshore stations and power cables" shall be applied.

For each offshore structure site, the set of available survey results shall be used for deriving an individual geotechnical subsoil model for the site that shall be used as the basis of the verifications. For this purpose (at least) one suitable calculation profile (subsoil profile) shall be specified with the required characteristic subsoil parameters of its subsoil layers. If the subsoil is non-homogenous, it may be necessary to formulate a more complex subsoil model for each offshore structure site with several calculation profiles.

The characteristic parameters and their probable bandwidths of all subsoil characteristics that are relevant for verification shall be defined and specified for the subsoil model. This data shall be based on the evaluation of a bandwidth of investigation results and on an expert's opinion based on experience, correlation and/or interpretation of direct and indirect information and investigations at the site.

The values of the applied subsoil parameters shall be derived from the bandwidth of characteristic values with regard to their significance in whichever calculation model is used. Variations in model calculations shall be provided to an appropriate extent. This shall also apply analogously to the parameters in all cyclic and dynamic investigations.

3.3.2.4 Limit states for verifications

A differentiation shall be made between the following limit states:

- Ultimate Limit State – ULS
- Fatigue Limit State – FLS
- Serviceability Limit State – SLS
- Accidental Limit State – ALS, in as far as such conditions exist.

3.3.2.5 Required verifications

3.3.2.5.1 Verification of the stability of the seabed

It shall be demonstrated that the subsoil system on which the verifications for the foundation and load calculations for the support structure are based is stable.
The following items are to be considered in particular:

- Potential reduction in stability of the seabed due to external influences, such as current and wave action, influenced by the substructure, effect of earthquake, offshore operations such as pile driving or dredging etc.
- Potential change in the geometry of the seabed due to influences such as erosion (scouring) and suffosion

- Potential change in the arrangement of foundation elements due to influences such as cyclical creep of the subsoil, accumulated deformation (hysteresis) and
- Potential change in the mechanical properties of the subsoil due to influences such as pore water pressure accumulation (liquefaction), consolidation, deconsolidation.

It shall be demonstrated that
- either these mechanisms do not occur
- or that these mechanisms have been adequately taken into account in the design
- or that these mechanisms will be adequately observed during installation and operation and that suitable measures will be taken to compensate for them if necessary.

3.3.2.5.2 Verifications for foundation elements

As a minimum requirement, the following shall be investigated, documented and given due consideration in all respective verifications:
- The process engineering of the installation and effects of the installation process
- The description and modelling of the significant interactions between the subsoil and the structure as the basis and input parameters
  - for the verifications pertaining to the external load capacity of the foundation and its elements
  - for the verifications pertaining to the internal load capacity of the foundation elements and
  - for the natural frequency analysis of the offshore structure
- The influence of stability properties of the seabed on the stability against collapse and on the serviceability of the foundation, the entire structure and its components in accordance with B3.3.2.5.1
- The effects of cyclic and dynamic loads (degradation and liquefaction)
- The constraint stress on structural elements and add-on components due to permanent subsoil deformation
- The safety against shifting of ballast material.

For all verifications pertaining to foundation elements, the lower and upper limits for the relevant subsoil parameters shall be varied in an unfavourable combination. Where the ductility of the subsoil and the structure is adequate, verifications based on characteristic parameters are sufficient; the respective ductility shall be demonstrated. As a minimum requirement, the lower and upper limits for the stability of the foundation elements shall be determined and varied in an unfavourable combination for the purpose of analysing the natural frequency of the overall systems.

Special verifications which are required for pile foundations:
- The axial pile load capacity and safety
- The lateral pile load capacity and safety
- Axial deformation and shifting estimates (settling, inclination and rotation)
- Lateral deformation and shifting estimates and
- Pile group effects and interactions between individual foundation elements (e.g. in tripile, tripod and jacket structures).

The axial pile load capacity shall be demonstrated through conducting a sufficient number of dynamic pile load tests. When these tests are to be carried out depends on the forecasting method used. For further information, please refer to Appendix 3-III.
Special verifications which are required for heavyweight foundations:

- External stability against collapse (safety against tilting, sliding and bearing capacity failure), if necessary under consideration of a potential pore water excess pressure build-up
- Subsoil loads through normal subsoil stress and limitation of the open gap and
- Settling estimates under full load conditions and accumulated settling when subjected to cyclic loads.

For special types of foundation (e.g. suction anchors, suction caissons), verifications shall be obtained in a similar way to that specified for pile and heavyweight foundations, in consultation with the BSH. In this case, the BSH may engage the services of suitable assessors.
Suitable structural design criteria shall be defined for the deformation and shifting verifications based on the potential static and dynamic effects on the components and on the structure, e.g. max. permitted deflection and torsion at the pile head at the level of the seabed and at the pile foot, max. exploitation of the lateral bedding reaction of the subsoil and minimum or maximum values for subsoil stiffness.

An expert assessment shall be conducted with regard to the effects of the following parameters and how they can be practically considered in the verifications:

- Installation of the foundation elements on the subsoil and foundation system, e.g. piling; driving aids
- Positional shifts of the foundation elements
- The exceeding of manufacturing tolerances
- Deviations in piling depths.

3.3.2.5.3 Verifications pertaining to the ability of the foundation elements to interact with the support structure

For the support structure, in addition to the inclination forecast required in the serviceability verification, it shall be demonstrated that constraint stress exerted on the support structure as a result of potential differences in the shift of the individual foundation elements can be reliably and sufficiently absorbed. Any resulting changes in the loads exerted on the foundation elements by the support structure shall be taken into account in the verifications for the foundation elements.

3.3.2.5.4 Geotechnical component tests

In the case of deficient subsoil conditions, or where the respective foundation and design methods have not yet been sufficiently tested, the BSH reserves the right to demand that comparable (with regard to the subsoil, pile geometry and installation procedure) foundation elements be manufactured in advance so that they may be tested for their suitability with respect to their intended purpose.

These examinations shall be conducted well in advance so that the results can be used in the design phase. Accordingly, the verified results are generally required to be submitted for the 2nd release.

3.3.2.5.5 Additional geotechnical information and verifications

All presumptions made with respect to the devised foundation elements and the preconditions for realising the construction project shall be accordingly specified.

All geotechnical verifications which will have to be presented for the devised foundation elements during the installation and operating phases (please refer to chapters B3.4.4 and B3.5.4) shall be accordingly specified.

3.3.3 Geotechnical documents to be submitted

3.3.3.1 Geotechnical design report

The design, calculations and dimensioning of the foundation elements shall be accordingly represented in the geotechnical design report in a verifiable manner. The formal and content requirements set down in DIN EN 1997 (EC 7) placed on the foundations of offshore structures are detailed more precisely in the following:

The Geotechnical Report of the expert for geotechnics compiled in accordance with the *BSH Standard Ground Investigations* represents the basis on which the Geotechnical Design Report is based but is not an integral part of this report. The Geotechnical Design Report contains all relevant information and representations with respect to the design of the foundation elements, in particular

- The presentation of the assumptions made based on the scope for making selections and decisions provided by the applicable standards, and the justification thereof. These include, in particular
  - The selection of subsoil parameters used
  - Where necessary, reasons for deviations in the applied subsoil parameters from those detailed in the geotechnical report
  - The determination of the load combinations relevant to the calculations
  - The classification of the load combinations in different calculation situations
  - The assignment of safety factors to loads and resistances and
  - The representation of the implementation and assessment of component tests, e. g. pile load tests, incl. specific representation of the verification methods used
- The representation of the engineering models used for the verifications, including the model assumptions and simplifications used
- The representation of the calculation processes used for the verifications, including their implicit prerequisites
- The values of the subsoil parameters used for the verifications
- The derivation of the values for model parameters additionally required
- The results of the load-bearing capacity verifications
- The results of the serviceability verifications
- The representation of the appropriateness and the adequacy of the examined ultimate limit state
- The representation of the appropriateness and the adequacy of the examined serviceability limit state
- Recommendations for measurements conducted on the structure and on the subsoil (monitoring), as well as

- Where necessary, the justified representation of the necessity, the appropriateness and the adequacy of the observation method and
- Information detailing all the certificates and verifications of the preconditions to be presented during the installation and operating phases.

Whilst construction is under way, the construction-specific supplementary geotechnical reports, together with their verification components, will be added to the geotechnical design report as construction progresses. These include the evaluation and assessment of component tests, such as dynamic pile load tests, the documentation and assessment of installation logs (pile-driving logs, injection logs etc.), as well as the evaluation and assessment of the effects of deviations of the installation results from the assumptions, preconditions and provisions set down in the geotechnical design report.

3.3.3.2 Geotechnical as-built documentation (geotechnical installation report)

Once the installation of the foundation elements has been completed, a verified geotechnical installation report shall be presented. This geotechnical installation report constitutes the "Geotechnical component of the as-built documentation".

Based on the geotechnical design report, this installation report shall contain all the relevant information concerning the implemented installation with respect to the stability and the serviceability of the foundation elements, in particular compliance with and deviations from the assumptions, preconditions and provisions applying to the verifications regarding the geotechnical design in accordance with chapter B3.3.3.1.

3.3.3.3 Supplementary reports to the geotechnical design report

In as far as the data and findings required for the safety verifications only become available during the actual installation of the foundation elements, appropriate supplementary reports to the geotechnical design report shall be developed by the planning expert for geotechnics. These shall include respective references to the geotechnical design report in accordance with B3.3.3.1.

In as far as the installed foundation elements deviate from the assumptions, preconditions and provisions applying to the verifications of the geotechnical design report, supplementary reports to the geotechnical design report shall be developed to certify that the stability and serviceability of the foundation elements is maintained under the deviating conditions.

3.3.3.4 Documents to be submitted for the 2nd release

The following verified geotechnical documents shall be included with the application documentation for the 2nd release. All documents shall comply with the BSH Standard Ground Investigations:

[Doc. No. 320] Main ground investigation report

[Doc. No. 321] Subsoil and foundations survey (design phase) as well as the

[Doc. No. 322] Geotechnical design report and

[Doc. No. 323] Where necessary, supplementary expert opinion on cyclic loads ("cyclics")

[Doc. No. 324] Report from the company conducting the dynamic pile load tests, including details on the planned sensors, their respective installation and planned cable routes

[Doc. No. 325] Confirmation of the feasibility of dynamic pile load tests to be supplied by the architect, taking all the relevant effects on the foundation installation process into account (e. g. allowing for a cofferdam when installing sensors and laying cables)

[Doc. No. 326] Verification report(s) pertaining to Docs. No. 320, 321, 322, 323, 324 and 325.

3.3.3.5 Documents to be submitted for the 3rd release

The following verified geotechnical documents shall be included with the application documentation for the 3rd release:

[Doc. No. 330] Design and project-specific supplementary geotechnical reports

[Doc. No. 331] Verification report pertaining to Doc. No. 330.

Any supplementary geotechnical reports that may also need to be submitted for the 3rd release shall comply with the project-specific stipulations resulting from previous approvals, permits, authorisations and orders issued by the BSH.

3.4 Implementation phase

3.4.1 Preliminary remarks

The installation of the foundation elements, as well as the possible need to prepare the subsoil conditions in line with the planning documentation, have an effect on the intended functionality of the foundation and shall be planned and implemented accordingly.

The monitoring of the production of the foundation elements shall comply with the corresponding guidelines for support structures detailed in chapter B2.4.2.1.

3.4.2 Technical codes of practice

The technical codes of practice to be applied whilst the foundation elements are being constructed are derived from DIN EN 1997 (Eurocode 7) and the normative references contained therein.

3.4.3 Requirements and required verifications

Special underground engineering processes are applied during the foundation element installation process. The approval holder is responsible for ensuring that these are monitored onsite by an expert and accordingly examined by the appointed inspector.

Whilst the foundation elements are being constructed, all the required observations to be able to assess the success of the installation and to verify the geotechnical assumptions and preconditions detailed in the design document shall be made by the monitoring expert and documented for the geotechnical installation report.

3.4.4 Geotechnical documents to be submitted when applying for operating release

[Doc. No. 340] Geotechnical as-built documentation in accordance with chapter B3.3.3.2

[Doc. No. 341] Report on the results of the dynamic pile load tests

[Doc. No. 342] Supplementary reports to the geotechnical design report and other verified reports in compliance with BHS stipulations

[Doc. No. 343] Verification report(s) pertaining to Docs. No. 340, 341 and 342.

3.5 Operating phase

3.5.1 Preliminary remarks

Foundation elements are not subject to any specific operating requirements during the operation of the installation once they have been appropriately and professionally installed.

In order to monitor the overall behaviour of the foundation elements during the operating phase, parameters, such as shifting, deformation, component stress and frequencies, shall be measured and recorded (monitoring) in the area of the foundation elements at representative offshore wind turbine sites. These sites shall be selected in coordination with the geotechnics expert. Based on these results, the compliance of the interaction between the subsoil and the structure with the design and planning results shall be regularly examined and assessed by an expert within the scope of the periodic inspections.

For all types of offshore structures, special requirements resulting from specific installation results or special demands as a result of innovative new foundation principles may arise during the normal operations.

For measures introduced during normal operations, the level of stability of the foundation elements against collapse is generally verified using the observation method.

3.5.2 Technical codes of practice

The geotechnical codes of practice to be applied during the operating phase are derived from DIN EN 1997 (EC 7) and the references contained therein and comply with the features of the foundation elements contained in the specific design documentation.

3.5.3 Requirements and required verifications

The requirements and required verifications shall comply with the respective project-specific stipulations resulting from the approvals, permits, authorisations and orders issued by the BSH.

3.5.4 Documents to be submitted for maintaining the operating permit

The documents to be submitted with respect to maintaining the operating permit, shall comply with the respective project-specific stipulations resulting from the approvals, permits, authorisations and orders issued by the approval authority responsible for granting the operating permit.

3.6 Decommissioning phase

3.6.1 Preliminary remarks

The manner and scope of decommissioning work on the foundation elements shall comply with the project-specific stipulations resulting from previous approvals, permits, authorisations and orders issued by the BSH.

3.6.2 Technical codes of practice

The geotechnical codes of practice to be applied during the decommissioning phase are derived from DIN EN 1997 (EC 7) and the references contained therein and comply with the features of the foundation elements contained in the specific design documentation.

3.6.3 Requirements and required verifications

The required geotechnical verifications shall comply with the respective project-specific stipulations resulting from the approvals, permits, authorisations and orders issued by the BSH.

3.6.4 Documents to be submitted when applying for decommissioning release and final declaration

The geotechnical documents that need to be submitted for the decommissioning release and the final statement shall comply with the project-specific stipulations resulting from previous approvals, permits, authorisations and orders issued by the BSH.

4 Rotor/nacelle assembly

4.1 Preliminary remarks

Generally, a type certification shall be presented for the planned rotor/nacelle assembly. In the case of a pilot installation or a new development for which, due to time restrictions, a type certification cannot or cannot yet be issued, it may be permissible to present another suitable certificate for obtaining approval for the RNA in exceptional individual cases. The objective of the type certification, resp. permissible alternative certification which may be presented in exceptional cases, is to ensure that the respective turbine type is inspected by an expert with the view to confirming that it has been designed and documented in compliance with the underlying standards and guidelines so that it may be manufactured on this basis. Due consideration shall be given to the local marine environment during this process. In order to obtain the type certification, proof shall be provided that the offshore operation of the wind turbine complies with the respective standards and guidelines.

As a result, the type certification shall incorporate the following tasks:

- Design evaluation of the turbine type:
  - Loading assumptions
  - Technical management and safety concept
  - Rotor blades (including static, resp. dynamic blade tests, in as far these are required by the type certification guidelines applied)
  - Engine
  - Optionally, tower (not including the substructure, however including the connection to the tower and the substructure and their respective properties, in as far as this is required with a view to assessing the other components, e.g. stiffness assumptions)
  - Electrical systems and lightning protection, as well as
  - Commissioning inspection for one of the first offshore wind turbines of the tested type.
- Implementation of the design requirements during the production and installation phase; a one-time monitoring and inspection of the production process shall ensure that the design requirements specified in the implementation documents with respect to the production and installation can be accordingly achieved at the manufacturing company.
- QM system used by the offshore wind turbine manufacturer: The use of an effective, certified management system in accordance with ISO 9001 (Quality management systems – Requirements) shall be accordingly verified. Alternatively, should this not be currently available, arrangements can be made with the appointed inspector to inspect the quality management system on the basis of ISO 9001.
- Prototype measurements.

The following measurements, resp. tests, shall be carried out on one of the first prototypes (e.g. prototype on land):

- Loads
- Performance curve
- System behaviour.

Once the type certification has been presented, the project and site-specific inspections shall be conducted and the monitoring services provided (please refer to chapter B1).

4.1.1 Technical codes of practice

The following primary codes of practice for the verification of offshore wind turbines shall apply:

DIN EN 61400-22	Wind turbines – part 22: Conformity testing and certification, German version EN 61400-22:2011
DIN EN 61400-3	Wind turbines – Part 3: Design requirements for offshore wind turbines
GL-IV-2	GL Rules and Guidelines, IV Industrial Services, Part 2 Guideline for the Certification of Offshore Wind Turbines

In the following, a type certification based on the codes of practice listed above shall be termed an "offshore type certification".

Codes of practice for the verification of onshore wind turbines are not sufficient as these do not cover marine conditions. An existing "onshore type certification" may be extended under application of the above offshore codes of practice in consultation with the appointed inspector.

4.2 Development phase

4.2.1 Preliminary remarks

Generally, the decision to implement a specific offshore wind turbine type is not yet made during the development phase. However, in order to be able to assess the technical feasibility of the project and compile the preliminary design of the foundation concepts, minimum basic technical parameters for the rotor/nacelle assembly are required. These parameters shall be provided as a range of parameters, or as maximum values, so as to be able to include different installation types in the considerations.

4.2.2 Requirements and required verifications

The following basic parameters describing the offshore wind turbine shall be submitted during the development phase:

- Rotor diameter
- Hub height (above the mean sea level)
- Rated output
- Installation type (axial direction, output control, number of rotor blades, windward or leeward runner): Should the planned installation type deviate from the current state of the art (horizontal rotation axis, variable rotational speeds, adjustable blade pitch, windward runner), a more exact description of the planned installation shall be submitted at this point which shall include a complete technical specification sheet.
- Number of installations and wind farm configuration (erection plan and respective installation types)

These basic parameters shall be submitted as "from-to" figures or maximum values. As a result, the decision to implement a specific type of installation is not required during the development phase. With regard to the preliminary design of the foundation concepts, it may be necessary to supply preliminary loading assumptions for the rotor/nacelle assembly.

4.3 Design phase

4.3.1 Preliminary remarks

In the following considerations, the assumption is made that the wind turbine type has already been selected at the point of reviewing the design and that a valid offshore type certification for this turbine type is available. In the case of a pilot installation or a new development for which, due to time restrictions, a type certification cannot or cannot yet be issued, it may, in individual cases, be permissible to present another suitable verification for obtaining approval for the RNA, where this has already been accordingly clarified.

Once all the verification reports pertaining to the site conditions, loading assumptions and support structure have been presented, a certificate of conformity for the rotor/nacelle assembly is generally issued by the appointed inspector. The design review phase is concluded through the issue of the certificate of conformity.

The preconditions for issuing the certificate of conformity are that there have been no changes to the RNA (technical management and safety system, engine, rotors, electrical systems) with respect to the offshore wind turbine type certification, that the site-specific loads on the RNA do not exceed the permissible loads specified in the type certification and that the influence of the local marine environment has been accordingly taken into account through the implementation of a climate control system, corrosion protection and similar in the respective type certification.

4.3.2 Requirements and required verifications

Based on the site conditions and the design basis, as well as the technical management and safety concept of the offshore wind turbine, the site-specific loading conditions relevant to the design shall be accordingly defined. The scope of the loading condition definitions shall be assessed by the appointed inspector. It is recommended for the loading conditions to be evaluated by the appointed inspector before the simulation and calculation of the loading assumptions starts, in order to avoid duplicate simulations. All loading conditions shall be considered that are necessary in order to demonstrate the structural integrity of the offshore wind turbines.

A basic differentiation is drawn between operational stability loads for demonstrating operational stability and extreme loads for demonstrating general stability against collapse (strength, stability, external stability against collapse). The operational stability loads shall represent operation of the offshore wind turbines over a service life of at least 20 years. Should the designated service life be less than the 25-year approval period, appropriate verification shall be submitted in good time prior to the end of the designated service life with a view to continuing operations (e.g. based on the "DNV GL Guideline for the Continued Operation of Wind Turbines"). The extreme loads shall include all events that can lead to the greatest possible loads, whereby consideration shall be given to the probability of their simultaneous occurrence (e.g. "50-year gust", "50-year wave", extreme angle of approach of the rotor, collision with a service ship, ice pressure).

The combination of external conditions and installation statuses shall be represented and justified for the corresponding project and the site according to (or if necessary based on) the applicable guidelines and standards. The partial safety factors of the effects of the codes of practice used shall be taken into account. The calculation methods, e.g. simulation processes, number of implementations and combination of wind and wave loads, shall be described and any simplifying assumptions shall be justified.

Once the loading condition definitions have been defined and evaluated, load calculations shall be performed with regard to the complete structural dynamics and presented to the appointed inspector for examination. The appointed inspector shall check the plausibility of the loading assumptions and the results based on exemplary calculations. The comparison between parallel calculations and those in the presented load calculations shall form a basis for the decision on whether to accept the loading assumptions and to issue the verification report for the loading assumptions.

Should the site-specific loading assumptions be below those specified in the type certification, the certificate of conformity for the site-specific design review of the RNA may be issued.

Should the site-specific loading assumptions exceed those specified in the type certification, the stress reserve for all components affected by the increased loads shall be reviewed – which may possibly require the design to be accordingly modified – and submitted for examination. In this case, the certificate of conformity for the site-specific design review of the RNA shall be issued following the inspection of the stress reserve and possible modification of the design.

4.3.3 Documents to be submitted when applying for the 2nd release

[Doc. No. 420] Offshore type certificate for the tested installation type including the verification reports and certificates of conformity on which this is based

[Doc. No. 421] Site-specific loading assumptions, incl. reserve verification

[Doc. No. 422] Site-specific modifications to the RNA, where required and

[Doc. No. 423] Verification report pertaining to Docs. No. 421 and 422 and certificate of conformity pertaining to the site-specific design review.

4.4 Implementation phase

The requirements pertaining to the implementation phase are specified in chapter B1.3.4. The RNA components to be given consideration during the monitoring of the production phase and the respective production processes are to be specified for the project in question in accordance with chapters B1.3.4 and B2.4.2.1 – but shall include at least the following main components:

- Rotor blades
- Rotor hub
- Rotor shaft or king pin
- Machine frame
- Nacelle installation
- Other components, the failure of which could destroy the RNA or endanger humans

4.5 Operating phase

Proper operation of the RNA is crucial to the structural integrity and stability of the offshore wind turbine. The requirements pertaining to the operating phase are described in chapters B1.3.5 and B2.5.3 as well as in Table 4-1 below.

Assembly	Test item
Rotor blade	Damage to the surface, cracks, structural inconsistencies of the blade body. (Inspection from a lifting platform or climbing device or pulley system: Visual assessment and inspection of the structure using suitable processes (e. g. knocking, ultrasound)). Tightening torque of screw connections. Damage to lightning protection equipment.
Drive train	Leaks, unusual noises, condition of the corrosion protection, lubrication condition, tightening torque of screw connections. Condition of the gear unit
Nacelle and power and torque-transmitting components	Corrosion, cracks, unusual noises, lubrication condition, tightening torque of screw connections
Hydraulic system, pneumatic system	Damage, leaks, corrosion, function
Safety equipment, measuring sensors and brake systems	Function checks, compliance with limit values, damage, wear
Documents	Completeness, compliance with regulations, implementation, test documents, regular undertaking of maintenance, possibly including authorised modifications/repairs.

Table 4-1: Minimum requirements pertaining to the periodic inspection of the RNAs of offshore wind turbines.

4.5.1 Requirements and required verifications

4.5.1.1 Evaluation criteria for the periodic inspections

The evaluation criteria for the periodic inspections shall be defined in the test and inspection plan according to the respective installation and site.

4.5.1.2 Scope of the periodic inspections

The stability against collapse of the RNA, including the function of the safety and brake systems, shall be inspected. The items covered by the periodic inspections are detailed in chapter B2.5.3 (support structures for the RNA) and in Table 4-1 above.

4.5.1.3 Periodic inspections – inspection intervals

The periodic inspections of the RNA shall be carried out on at least 25 % of the wind turbines at the offshore wind farm so that all the RNAs are inspected in a four-year cycle. This period commences when trial runs are started.

Based on empirical values and verification of the status through respective inspections, it is possibly to deviate from the prescribed annual test intervals in consultation with the appointed inspector and the BSH.

4.5.2 Documents to be submitted when applying for an extension of the operating permit

[Doc. No. 450] Annual verification report by the appointed inspector summarising all the RNAs (summary of the results of the periodic inspections, please refer to chapters B1.3.5 and B2.5.3)

[Doc. No. 452] Certificate of conformity pertaining to the operation of all the RNAs at the wind farm (incl. the periodic inspections).

4.6 Decommissioning phase

The requirements pertaining to decommissioning are specified in chapter B2.6.

5 Operational structure of offshore stations (topside)

5.1 Preliminary remarks

Verification shall be provided that the operational structure of the offshore station (topside), including its supporting components, as are to be found in self-erecting offshore stations, for example, is resistant against the effects and stresses of site-specific demands and meets the applicable standards, regulations and guidelines. The site-specific external conditions, such as wind conditions, ice accretion and special circumstances shall be taken into account here.

For all the component verifications listed hereinafter, there shall always be a check of whether the verification or at least parts of it shall be conducted on the static total system.

At an early planning stage, a functional description of the offshore station and, if necessary, more detailed concepts to describe the type, scope and design of the operational structure (topside) shall be drawn up. The functional description represents the basis for the development and design of the whole structure and shall be updated as the project progresses with more concrete information in the form of detailed concepts and drafts for the design of the offshore station. The functional description and the concepts tailored to it shall be submitted to the appointed inspector, who shall draw up verification reports and certificates of conformity for the relevant releases, see Table 1-2.

The requirement to compile the functional description and concepts shall furthermore ensure that design and structural requirements resulting from occupational health and safety are sufficiently taken into account as these plans are developed in more detail.

For high-voltage and medium-voltage components on the offshore stations (including the high-voltage and medium-voltage cables) it is not necessary for the design to be examined and for inspections to be undertaken during the implementation and operating phase in order for the releases to be granted.

5.1.1 Classification into danger, protection and safety zones

Offshore stations and their immediate vicinity, which shall be specified in more detail in the course of a project, shall be subdivided into spatially separate zones according to their use and the associated hazards. This subdivision places structural or technical demands on the zone in question.

Danger zones are zones where it must be expected that persons present in the zone and in the immediate vicinity are at risk. These are, for example, zones in which hazardous goods are stored or handled, zones where there is a risk of explosion, zones with an increased fire risk, zones with load handling (where cranes are used) or zones where there is an increased risk of falling.

Danger zones with a high risk potential (e.g. zones where there is a risk of explosion, and zones with high fire loads or fire risks) shall be separated from protection zones where increased demands are placed on the protection of the persons present in this zone (e.g. sleeping accommodation, social areas, passageways, and escape and evacuation facilities).

Safety zones are zones whose purpose is to safeguard the operation of the offshore station, on the one hand, and to protect unauthorised persons from hazards, on the other. These can be areas with electric power installations (high voltage), control centres, transformer installations, technical services zones for emergency operations, helicopter landing pads, winch operation areas (winch-down platform) or boat landings.

Danger zones outside the offshore station shall be taken into account and specified to the extent that hazards caused by falling parts or suchlike, by collisions, or by smoke and fire drifting to structural works in the vicinity or to watercraft, for example, are kept as low as possible.

Danger zones shall furthermore be separated from safety zones whose function and equipment are indispensable for the safe operation of the offshore station.
Danger, protection and safety zones shall already be shown in a layout plan in the development phase of the offshore station and shall be updated with more detail in the subsequent design phase.

5.2 Development phase

5.2.1 Preliminary remarks

The starting point is a functional description of the offshore station whose purpose is to present the safety of all persons and the environment in a way that can be substantiated and verified. This covers all operating phases and states as well as emergency situations. The functional description is the fundamental requirement for the design of the offshore structure, where requirements from occupational health and safety shall be iteratively taken into account in the design as the planning progresses, and expressed in more concrete terms by means of detailed concepts which shall submitted to the appointed inspector for inspection.

As early as the development phase, the design should be based on a full safety assessment tailored to the whole structure in accordance with the requirements of occupational health and safety. It is a good idea to give consideration to these functional and technical requirements at an early stage of the development process, since their final design has to be included during the design phase of the topside at the latest. According to chapter 5.2.4, only the verification report of the appointed inspector for this study has to be submitted to BSH at the time of the development phase. The following aspects concerning the implementation of their design in the functional description and individual concepts, if applicable, serve here as topical proposals intended to describe the planned modes of operation of the operational structure (topside) in a comprehensible way:

- Operational concept (incl. transport, installation, commissioning, maintenance, shut-down and decommissioning):
  - Operating situations, such as normal operation including winter operation, operation when malfunctions occur, or emergency operation
  - Transport and installation states
  - Operating modes, such as manning, mother-daughter concept
  - Interior spaces (e. g. technical services zones, sleeping accommodation, offices, communal spaces, first aid room, workshops, stores, control and communication rooms)
  - Operational or weather-related limitations, such as safe accessibility of parts of the installation, for example
- Behaviour of the structure should a ship collide with it
- Subdivision into protection and danger zones (explosion zones, high-voltage areas and others) in accordance with the occupational health and safety requirements and the design requirements resulting therefrom
- Design concepts for the different fire scenarios from the aspect of fire and explosion protection (transformer, living accommodation, workshops, store, tanks etc.):
  - Illustration of fire compartments
  - Fire detection system (fire detection on decks and in rooms, for example)
  - Fire protection (passive (e. g. thicker walls) and active (stationary and mobile fire-fighting systems))

- Supply and disposal (according to the “as low as reasonably practicable” (ALARP) principle):
  - Bunker concept
  - Refuelling concept
  - Waste concept
  - Wastewater concept
  - Pumping out concept
  - Consideration of environmental aspects (e. g. MARPOL) and
  - Requirements placed on catchment and drainage systems (particularly for the helicopter landing pad)
- Emergency management:
  - Evacuation, e. g. escape routes, primary and secondary rescue appliances
  - Emergency supply
- Transport and access:
  - Use and number of access systems: Boat landings; areas with winch operations (winch-down platform); helicopter landing pad etc.
  - Transport and load handling (zones where cranes operate etc.)
- Planned method and schedule for building, installation, operation and decommissioning
- Concept for fixtures and fittings (for accommodation modules)
- Safety aspects for layout and installations and
- Safety demands and functional requirements placed on equipment.

5.2.2 Technical codes of practice

The technical codes of practice for the support structure are listed in chapter B2.3.1.

For information on the design of the structural steel part of the operational structure for offshore stations, reference is made to Appendix 5 (Application notes for the BSH Standard Design – “Minimum requirements concerning the constructive design of offshore structures within the Exclusive Economic Zone (EEZ)”).

5.2.3 Requirements and necessary verifications

Supplementary to the information listed in chapters B2 and B3, the design basis shall contain the following information:

- Functional specifications and requirements placed on the primary and secondary support structures of the offshore station
  - Site conditions of the operational structure and the support structure of the offshore station
  - Approach paths for helicopters, if applicable
  - Preliminary cable layout and routing and
  - Max. height of the structure

- Conceptual consideration of the following areas: Explosion protection zones, noise areas, escape and emergency access routes, winch and helicopter areas, crane areas, safety zones for electrical installations, control and remote control systems, and communication systems. These conceptual explanations are to be treated in the same way as the proposed topics listed at chapter 5.2.1 and serve to ensure that the safety-related requirements, which shall be shown in detail for the design phase at the latest, are considered at an early stage of the design. These conceptual explanations shall be agreed with the appointed inspector, who shall draw up a verification report in respect of this (Doc. No. 510) (please refer to chapter 5.2.4).
- Graphic representation of the preliminary drafts.

5.2.4 Documents to be submitted for the 1st release

[Doc. No. 510] Inspection report of the appointed inspector on the functional description of the offshore station.

[Doc. No. 511] Design basis

[Doc. No. 512] Inspection report pertaining to Doc. No. 511

[Doc. No. 513] Preliminary design

[Doc. No. 514] Inspection report pertaining to Doc. No. 513

[Doc. No. 515] Certificate of conformance to specify the design bases

5.3 Design phase

5.3.1 Preliminary remarks

When designing the operational structure of the offshore station (topside), all loads acting on the operational and support structure of the offshore station shall be determined. These include, in particular, the loads and dimensions of the electrical installations, the technical equipment, the rescue equipment and the tank and bunker installations with their respective contents. Furthermore, structural measures resulting from the risk assessment, such as the storage of hazardous goods, for example, shall be taken into account.

The following sub-chapters list and describe all documents (concepts) required from the viewpoint of the appointed inspector and which shall be submitted to the appointed inspector for inspection. It is not necessary to submit these documents to the BSH.

5.3.1.1 Load handling concept

The load handling concept shall cover the points listed below:

- The construction measures resulting from the planned manning (cabins, recreational rooms, mess rooms etc.), incl. the planned number of users and the loads resulting from this, shall be stated.
- Minimum requirements placed on transport and handling of materials and service fluids

The parameters of the particular system which are necessary for maintenance and repair shall be stated. These parameters shall be taken into account in the design of the support structure of the operational structure (topside). The basis for the system designs corresponds to the manufacturer’s information on the components, taking into account the relevant standards and occupational health and safety stipulations.

If the risk assessment results in demands being placed on the design, these shall be taken into account.

- Passageways, transport routes and storage areas

  Illustration and description of the different levels on the particular deck and the routes resulting from this on this deck and the operational structure of the offshore station (topside), including the effects of their loads on the structure.

  Cat ladders and step iron ladders are special types of passageway which are permissible only under certain conditions.

  Suspended loads, such as material transports in shafts or material transported by crane, shall also be taken into account.

  The following design requirements for transport thoroughfares (pedestrian and vehicle traffic), storage areas and means of transport shall be taken into account in the design:

  – Type
  – Connections
  – Layout
  – Dimensions
  – Description of the vertical and horizontal transport operations
  – Layout and type of the transport systems, lifting gear and crane systems
  – Information on the usability certificates of the transport systems, lifting gear, crane systems and the resulting additional load applied to the support structure
  – Description and illustration of the horizontal and vertical transport operations
  – Transport of heavy parts over machines and/or installations which are in operation
  – Repositioning of the helicopter using a crane (where necessary).

- The impact of the bunker stations on the design due to their dimensions and dead-weights shall be taken into account.

5.3.1.2 Fire and explosion protection concept

As early as the design phase, a fire and explosion protection concept shall be drawn up in accordance with the protection objectives to be laid down in the development phase; the concept deals with the applicable hazards and shall be updated during the course of the project when structural or technical changes are made. This fire and explosion protection concept could lead to design specifications, such as the use of fire partitions or fire-protection upgrading of support structures.

The fire and explosion protection concept shall contain at least the following requirements:

- Description of the operational structure of the offshore station (topside), incl. its load-bearing components, partitioning components and local situation regarding fire protection and the design details resulting from this
- Type of offshore station utilisation (long-term utilisation plan)
- Maximum number of persons working on the offshore station
- Fire load of the usable and storage areas
- Representation of the protection objectives and, in particular, a description of the important points of the protection objectives in relation to personal and environmental protection

- Representation of the fire protection measures to achieve the protection objectives by providing conceptual information which is necessary for the basic design (final design) of the operational structure (topside) and, where necessary, its load-bearing components.

This may result in design measures, such as including appropriate tanks of extinguishing agent. The fire and explosion protection concept forms the basis for the planning criteria to be specifically used to determine the preventive fire protection measures.

These fire protection measures shall be specified and illustrated while at the same time taking into account the technical and logistical possibilities of the project. The impacts of their dimensions and dead-weight on the design shall be taken into account here.

These measures shall contain at least the following design information:
Structural information

- Description and illustration of the 1st and 2nd emergency access routes and the layout of the escape route
- Description and illustration of the layout of fire-protection compartments and the design of their partitioning components, layout and design of smoke compartments (smoke control doors), closure of openings in components forming a compartment, and fire resistance of components (stability against collapse, room closures, insulation etc.)

Technical information on the installations

- Safety and/or emergency lighting with an illustration of the areas which have safety and/or emergency lighting, the type of system, and the design standard according to which the system shall be planned and installed
- Alarm systems with a description of how they are triggered and how they operate, the type of system, and the design standard according to which the system shall be planned and installed
- Automatic fire extinguishing installations with an illustration of the system type and the areas protected; assessment basis for the planning, installation and construction of the system
- Fire alarm system with an illustration of the areas monitored, the fire parameters and the location to which the alarms are sent, the type of system and the design standard according to which the system shall be planned and installed
- Description and illustration of further fire-protection installations, such as risers, wall hydrants, semi-stationary extinguishing systems, hand-held fire extinguishers, fire blankets etc.
- Smoke exhaust system with an illustration of the system, incl. the inlet air installations and the area to be kept smoke free (particularly for offshore stations which are permanently manned)
- Installations for keeping areas smoke-free with protection areas and measures for heat removal with an illustration of the type of installation and information on the design standard according to which the installation shall be planned and installed, and a ventilation concept, in as far as this affects fire protection, e.g. switching the ventilation systems from recirculating air to fresh air mode
- Information on the functional maintenance of installations, including emergency supply and the design standard according to which the system shall be planned and installed

- Description and illustration of lightning and overvoltage protection installations and the design standard according to which the system shall be planned and installed
- Description and illustration of special protection installations, such as those for hazardous materials
- Information and illustration of pressure generation systems (overpressure as well as negative pressure)
- Information on the requirements from the evacuation plan and the escape route plans and the design requirements resulting from this.

5.3.1.3 Access concept

The offshore station shall have means of access for staff and material. The construction measures resulting from the access concept shall be shown in detail; they shall contain the information below.

The concept shall consider the normal operation of the offshore station.

The following aspects at least shall be taken into account in sufficient detail:

- Definition of the field of application
  - Normal operation after erection, incl. maintenance, repair, standstill
- Description of the operational structure and the support structure of the offshore station in relation to its utilisation (offshore converter station, substations, accommodation etc.) and configuration (i.e. offshore station complex or individual structure)
- Site description, incl.
  - Environmental conditions to be expected (statistical annual view) and alignment with operational requirements or plans concerning frequency of use
- Planned number of persons or utilisation of the access systems (transport of persons, transport within the wind farm, normal operation or emergency)
- Planned means of access (helicopter landing pad, area with winch operation, static or active boat landing systems, crane systems). At least two independent means of access to the offshore station shall be provided.
- Restrictions on access:
  - Structural restrictions (e.g. loads, dimensions)
  - Weather conditions
  - Amount of swell
  - Tidal water levels
  - Wind speeds
  - Visibility conditions, incl. times of day
- Construction or structural requirements placed on access systems
- Requirements placed on means of transport (ship, helicopter, crane)
- Interfaces to other concepts (e.g. evacuation, operation).

5.3.1.4 Space utilisation plan

A plan for the utilisation of the spaces on the different decks shall be drawn up and shall state the distributed loads (e.g. position, dimensions and weight of the loads).

5.3.2 Technical codes of practice

The technical codes of practice for support structures are listed in chapter B2.3.1.
For information on the design of the structural steel part of the operational structure for offshore stations, reference is made to Appendix 5.

5.3.3 Requirements and necessary verifications

The following points shall additionally be shown for the operational structure (topside):

- Load calculation for the operational structure of the offshore station (topside)
- Definition and consideration of transport and installation states
- Compilation of the structural analysis of the final design for primary support structures
- Compilation of the structural analysis of the final design for secondary support structures, such as the work platform, boat landings, cranes, helicopter landing pad
- Implementation documents (plans, corrosion protection systems etc.)
- Verification of construction states and
- Collation and submission of the approval documents for the individual Technical Approval.

5.3.4 Documents to be submitted to apply for the 2nd release

[Doc. No. 520] Inspection report on the load handling concept, fire and explosion protection concept, access concept and space utilisation plan for the different decks of the operational structure (topside)

[Doc. No. 521] Final design of the primary and secondary support structure

[Doc. No. 522] Inspection report on the final design

5.3.5 Updating the concepts

The following concepts shall be updated and expressed in a more concrete form:

- Load handling concept
- Fire and explosion protection concept
- Supply and waste disposal concept with the following content:
  - Bunker and refuelling concept
  - Storage of hazardous goods
  - Waste disposal concept and
  - Catchment and drainage systems
- Evacuation concept
- Concept for emergency accommodation and accommodation modules
- Approval concept for components and systems
- Plan for monitoring the production and installation and
- Concept for onshore trials (if available).

The documents listed shall be submitted to the appointed inspector. The documents shall clearly show how the protection objectives are achieved. The documents shall have a level of detail which allows them to be aligned with the production. The appointed inspector shall carry out an inspection and compile a respective verification report which shall be submitted to BSH.

5.3.6 Installation manual

The requirements for the installation manual are stipulated in chapter B2.3.4.

5.3.7 Documents to be submitted to apply for the 3rd release

[Doc. No. 530] Inspection report on the updated concepts (please refer to chapter 5.3.5)

[Doc. No. 531] Installation manual (please refer to chapter B2.3.6)

[Doc. No. 532] Inspection report pertaining to Doc. No. 531

[Doc. No. 533] Decommissioning concept (feasibility of decommissioning)

[Doc. No. 534] Inspection report pertaining to Doc. No. 533

5.4 Implementation

5.4.1 Preliminary remarks

The inspected concept for the trial (please refer to chapter 5.3.5) shall be updated for the detailed planning.

The plan of the tests and trials shall be subdivided into three phases:

- Factory acceptance test and factory trial (FAT)
- Onshore trial (mechanical completion + HAT) and
- Offshore commissioning.

In this phase of the project, inspection and monitoring services shall be carried out primarily onshore, if possible.

The appointed inspector shall draw up a monitoring schedule on the basis of the planning for tests and trials. The monitoring schedule shall be coordinated with the applicant and the manufacturers before the work starts.

5.4.2 Requirements and necessary verifications

All requirements placed on the implementation phase are regulated in chapter B1.3.4.

The inspections which must be carried out during transport are listed in the installation manual.

The results of the inspections shall be described and assessed by the appointed inspector in the form of a comprehensible and plausible monitoring report.

5.4.3 Documents to be submitted to apply for operating release

[Doc. No. 540] Inspection reports and certificates of conformity

- For production monitoring
- Transport and installation monitoring and
- Monitoring of the commissioning phase

[Doc. No. 541] Corrosion protection – verification of the proper implementation (application) and the processing quality demanded

Verifications can be made on the basis of acceptance tests according to DIN EN ISO 12944-8, incl. the Annex hereto (form), or according to the corresponding Additional Technical Terms of Contract

[Doc. No. 542] Verification report of the appointed inspector with respect to Doc. No. 541 on the basis of the verification reports of the approval holder according to DIN 10204

[Doc. No. 543] As-built report

[Doc. No. 544] Inspection report pertaining to Doc. No. 543

[Doc. No. 545] Project certificate

5.5 Operation

5.5.1 Preliminary remarks

The requirements of the operating phase are described in chapter B1.3.5 and chapter B2.5.1.

For offshore stations, the position of the parts to be inspected and their different qualities (e. g. design safety factors) mean the inspections have different inspection intervals. On the basis of the test and inspection results and after a suitable operating period and number of inspections, these inspection intervals can be adjusted by applying for a deviation. This does not apply to intervals which are subject to statutory provisions or ordinances.

The following areas shall be included according to the intervals of their periodic inspection.

- All load-bearing structural elements of the offshore station which are crucial for the stability against collapse
- Other supporting elements which are crucial for the stability against collapse (e. g. structural bolts)
- The seabed composition
- Marine growth and
- Corrosion protection (coatings and anodes).

Which parts of the support structure must be inspected in each case depends on the type of structure. A distinction shall be made here between concrete and steel structures, for example. For the test and inspection plan, only the parts of the structure which ensure stability against collapse shall be taken into account.

5.5.2 Technical codes of practice

The technical codes of practice are listed in chapter B2.5.2.

5.5.3 Requirements and necessary verifications

The requirements and necessary verifications are regulated in chapter B1.3.5 and chapter B2.5.3.

5.5.4 Documents to be submitted to maintain the operating permit

[Doc. No. 550] Annual, summarising verification report of the appointed inspector (monitoring report – summary of the results of the periodic inspections, please refer to chapters B1.3.5 and B2.5.3),

[Doc. No. 551] Annual certificate of conformity for the test and inspection plan for the periodic inspections, which is compiled on the basis of the verification report in accordance with Doc. No. 550.

5.6 Decommissioning

The requirements for decommissioning are regulated in chapter B2.6.

6 Submarine cables

6.1 Preliminary remarks

The cables and accessories used must be state of the art and meet the requirements of the relevant standards in each case (selection see below) or their suitability must have been proven by comparable tests and they must be suitable for the particular operating conditions/ applications.

Reference is made to the specifications of the Spatial Offshore Grid Plan (BFO) in the current version. Only one approval is granted for the cabling within the wind farm and the power output cable.

6.2 Technical codes of practice

6.2.1 Cabling within the wind farm

For test requirements and suitability certificates, the following technical codes of practice in their current version must be complied with in relation to alternating current transmission using plastic-insulated power cables (energy distribution cables):
DIN VDE 0276-620 (VDE 0276-620)

IEC 60502-2	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m= 1.2 kV) up to 30 kV (U_m= 36 kV) – Part 2: Cables for rated voltages from 6 kV (U_m= 7.2 kV) up to 30 kV (U_m= 36 kV)

DIN VDE 0278-629-1 (VDE 0278-629-1)

IEC 60502-4	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (U_m= 1.2 kV) up to 30 kV (U_m= 36 kV) – Part 4: Test requirements on accessories for cables with rated voltages from 6 kV (U_m= 7.2 kV) up to 30 kV (U_m= 36 kV)

DIN EN 61442 (VDE 0278-442)

IEC 61442	Test methods for accessories for power cables with rated voltages from 6 kV (U_m= 7.2 kV) up to 30 kV (U_m= 36 kV)

6.2.2 Connection to the power grid

6.2.2.1 Alternating current transmission

For test requirements and suitability certificates, the following technical codes of practice in their current version must be complied with for alternating current transmission using plastic-insulated low-voltage, medium-voltage and high-voltage cables:
DIN VDE 0276-632 (VDE 0276-632)

IEC 60840	Power cables with extruded insulation and their accessories for rated voltages above 30 kV (U_m= 36 kV) up to 150 kV (U_m= 170 kV) – Test methods and requirements

DIN IEC 62067 (VDE 0276-2067)

IEC 62067	Power cables with extruded insulation and their accessories for rated voltages above 150 kV (U_m= 170 kV) up to 500 kV (U_m= 550 kV) – Test methods and requirements

If tests on high-voltage submarine cables cannot be performed in accordance with the aforementioned standards, reference is made to the CIGRE recommendations in their current version, published in the following issues of Electra (CIGRE in-house journal):

- CIGRE: Recommendations for Mechanical Testing of Submarine Cables. Electra Vol. 171, 1997.
- CIGRE: Recommendations for Testing of Long AC Submarine Cables with Extruded Insulation for System Voltage above 30 (36) to 150 (170) kV. Electra Vol. 189, April 2000.
- CIGRE: TB 490, Recommendations for Testing of Long AC Submarine Cables with Extruded Insulation for System Voltages above 30(36) to 500(550) kV.

6.2.2.2 Direct current transmission

The current version of the following CIGRE recommendation can be used for all direct current (DC) cables:

- CIGRE Recommendations for Mechanical Testing of Submarine Cables. Electra Vol. 171, 1997.

  The following CIGRE recommendations in their current version can be used for plastic-insulated high-voltage direct current (HVDC) cables:

- CIGRE: Recommendations for *Testing DC Extruded Cable Systems for Power Transmission* at a Rated Voltage *up* to 250 kV. Electra Vol. 206, 2000.
- CIGRE: TB 496, *Recommendations for Testing DC Extruded Cable Systems for Power Transmission* at a Rated Voltage *up* to *500 kV.*

  The following CIGRE recommendation can be used for cables with mass-impregnated paper insulation:

- CIGRE: Recommendations for Tests of Power Transmission DC Cables for Rated Voltages up to 800 kV. Electra Vol. 218, 2005.

6.3 Documents to be submitted for the approval

The following documents must be submitted 6 months before the start of the cable laying at the latest:

[Doc. No. 610] Technical description of the cables: incl. specifications of the cables, junction boxes, crossing constructions, laying equipment

[Doc. No. 611] Burial Assessment Study (BAS): On the basis of the evaluated results of the cable route survey (please refer to the *Standard Ground Investigations*, Part D) for the model of laying equipment which is actually available (so-called Installer BAS)

The following documents must be submitted 3 months before the start of the cable laying at the latest:

[Doc. No. 612] Construction plan incl. preparatory measures for the construction (e.g. pre-lay grapnel run, laying of a mattress when building crossing constructions)

[Doc. No. 613] Detailed description of the cable-laying procedure

As part of the approval procedure, BSH reserves the right to demand further verifications that the stipulated minimum burial depth is achieved.

Appendices

Appendix 1 Hull-retaining support structure for offshore wind turbines and offshore stations

As a rule, the evaluation of the behaviour in the case of a collision due to an offshore wind turbine is based on the appropriate standard incidental provision of the certificates of admission according to the SeeAnlV. It shall be assumed that the support structure of an offshore wind turbine is hull-retaining or “collision friendly”, if an offshore wind turbine, as a consequence of collision, does not fall onto the ship, the ship remains floatable and there is no leakage of pollutants. In practice, the evaluation of the behaviour in the case of a collision is conducted on a risk-based approach, i. e. the probability of a collision and the extent of possible damage to the ship and its crew as well as to the marine environment are all taken into account.

The method of risk classification and analysis shall be based on the German Hazardous Incident Ordinance (Störfallverordnung), the British Safety Case Regulations for offshore installations and the IMO regulations.

To evaluate the support structure, it is recommended to use the process described in Figure 1-I.1.

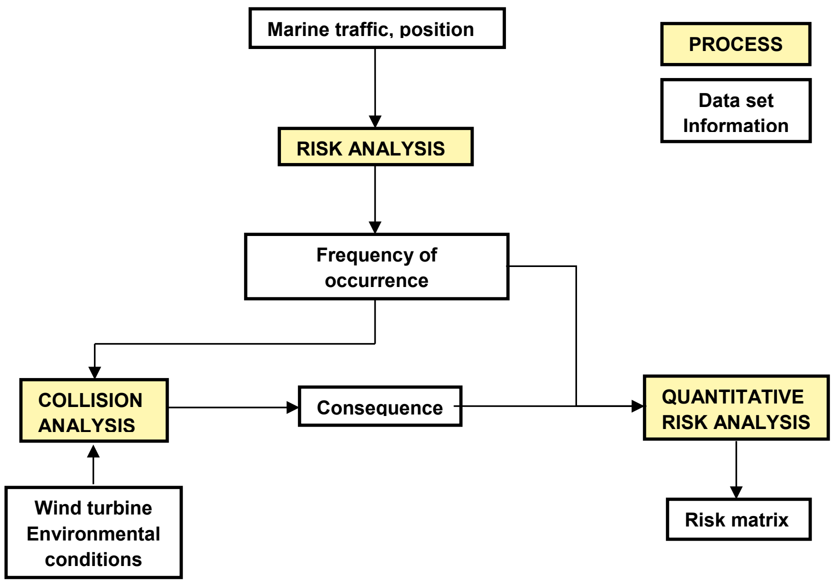


Figure 1-I.1: Flow-chart for hazard analysis

The evaluation of hull-retaining behaviour shall be conducted according to the following steps:

- Analysis of the frequency of occurrence of various collision scenarios. The frequency of occurrence is determined on the basis of the risk analysis introduced in the respective approval procedure, as well as in consideration of the criteria defined by the BMVI working group “Approval-relevant Recommended Guidelines” with regard to risk analysis and assessment. This must be based on the cumulative probability of occurrence in consideration of all systems planned or installed within the same space reserved for traffic.
- Selection of reference ships as a basis for the collision analysis,
- Collision analysis for selected scenarios, and
- Risk analysis and assessment on the basis of a risk matrix.

The individual steps are detailed in the following.

Frequency of occurrence

Marine transport within the relevant sea area shall serve to determine the frequency of occurrence. On this basis, possible danger statuses shall be identified and the respective probability of occurrence of each of these determined. The probabilities of occurrence shall be categorised as follows:

Qualitative	Probability of occurrence
[-]	[1/year]
Frequent	$H > 10^{-1}$
Occasional	$10^{-1} > H > 10^{-2}$
Rare	$10^{-2} > H > 10^{-3}$
Extremely rare	$10^{-3} > H$

Table 1-I.1: Probability of occurrence (cases per year)

The representative reference ships (according to type, size and gauge of the ship) to be used for the collision analysis shall be determined within the scope of the marine transport analysis in the relevant sea area. This selection is to be agreed upon by the GDWS via the BSH before compiling the collision analysis.

Collision analysis

Collision safety can be mathematically estimated using suitable simulation programmes. This includes, for example, FE programmes with an explicit solver for dynamic problems, such as *LS-Dyna, MSC.Dytran, Abaqus Explicit, Pam Crash.* Furthermore, processes have been developed for evaluating the collision safety of offshore platforms based on the yield hinge theory. These processes are implemented, for example, in the „*USFOS*“ calculation programme. There is a free choice of calculation method. Proof of applicability is to be provided.

The collision analysis determines the consequences of specified scenarios. To achieve this, the damage to offshore wind turbines as well as to ships, the environment and the safety of individuals shall be accordingly evaluated (Table 1-I.2).

Qualitative	Offshore Wind Turbine	Ship/Environment	Safety
Insignificant	Offshore wind turbine can continue to be operated	No or minor damage, no leakage of pollutants	No injuries
Significant	Offshore wind turbine defect, repair possible	Outer hull penetrated, operating materials from side tank/double floor flow into the water	Few injuries
Serious	Offshore wind turbine destroyed	Inner hull penetrated, loading tanks are leaking	Serious injuries, small number of fatalities
Catastrophic	–	Ship breaks apart, sinks	Large number of fatalities

Table 1-I.2: Consequences

While simulating the collision scenarios, the following criteria shall be observed:

Requirements concerning the offshore wind turbine model

- The model of the structure in its totality must be sufficiently detailed. Mass, inertial load and stiffness shall be considered.
- The bedding conditions shall be applied to the foundation elements by means of elastic springs (e. g. p-y model). Clamping at the top edge of the uppermost ground layer is not permitted.
- The material models and the failure criteria shall be selected and documented in a suitable manner.
- Details, such as boat landings, may be neglected if it can be guaranteed that these do not represent a supplementary danger to the integrity of the hull.

Requirements pertaining to the model of the ship

- The properties of the standard ship (geometry of the midship section, space of frame, thickness of the shell, position of the heavy fuel oil tank) shall be selected in consideration of the actual situation of the individual reference ship and shall be documented in detail.
- In addition to the mass and inertial loads of the ship, the hydrodynamic mass (approx. 20% of the mass of the ship) shall be considered.
- The boundary conditions for the movement of the ship shall be reasonably selected. For example, the force resulting from a change of draught or righting moment in the case of heeling shall be suitably integrated into the model. Rotation around the vertical axis shall only be permitted to a minor extent, or shall be excluded entirely, as such rotation results in minor damage to the ship and the offshore structure. This shall be achieved by appropriately selecting the boundary and/or the initial conditions.
- The calculation of the drifting velocity is based on the assumptions of the BMVI working group “Approval-relevant Recommended Guidelines” and shall assume a ship drifting sideways at 2 m/s. All other ship movements and the derivable consequences of these movements with respect to drifting towards an offshore structure (e. g. due to accelerations, displacements, and rotations) may be reduced to zero, if they cannot be represented realistically. Furthermore, single peak loads resulting from environmental conditions, such as wind, currents and swell, may be neglected, insofar as they are not representable in a realistic manner within the scope of the calculations. The respective assumptions included in the expert opinion are to be accordingly explained and justified. The ship does not have its own propulsion. Loads resulting from environmental conditions, such as wind and current, may also be neglected, insofar as these are not representable in a realistic manner.
- The material models and the failure criteria shall be suitably selected and documented, in particular for higher-tensile steel.

Quality criteria for the collision analysis

- Different scenarios are to be simulated, whereby the parameters (water level, angle of impact etc.) shall be selected conservatively.
- If simulations are used, the contact between the ship and the offshore wind turbine, as well as the contact between the individual components, shall be simulated in a suitable manner.
- The size of the elements shall be selected in such way that deformations (dents, bucklings, etc.) can be represented realistically.
- In particular, the element formulation (number of integration points, fully integrated or reduced integrated elements, no tetrahedron/triangle elements...) shall be carefully selected for the simulations. Particular attention is to be paid to the quality criteria inherent to the programme used for the elements (taper, skew etc.)

- The convergence criteria shall be documented for both implicit and explicit simulations. There shall be no major damping (material damping, etc.). Friction coefficients shall be selected reasonably.
- Energy distribution shall be considered in detail by the simulation. Changes of the total energy level, in particular, shall be documented.

Risk analysis and assessment

The quantitative risk analysis shall combine the results of the occurrence frequency with those of the collision analysis. This shall then be assessed on the basis of a risk matrix.

Please refer to the subsequent risk matrix for the respective risk priorities (Table I.3). The determined risk priority of each individual scenario shall not exceed level 4 for offshore wind turbines, resp. level 3 for ships, the environment and the safety of individuals.

Catastrophic	4	5	6	7
Serious	3	4	5	6
Significant	2	3	4	5
Insignificant	1	2	3	4
	Extremely rare	Rare	Occasionally*	Frequent*

Table 1-I.3: Risk matrix with risk priorities

Determining the Behaviour of Offshore Stations in the Case of a Collision

The requirements placed on a “collision friendly”, resp. hull-retaining method of construction shall also apply to all other offshore structures, such as offshore stations. However, when taking the above mentioned risk-based approach into account, there are some differences when it comes to the assessment of the behaviour of the support structure in the case of a collision. Among other things, it may be taken into consideration that the support structure of an offshore station may, due to the dimensions and construction methods involved, possibly be engineered with a higher strength in order to comply with the stability criteria. Furthermore, because of the relatively small number of substations and converter platforms compared to the number of offshore wind turbines, and due to the size of the traffic areas actually occupied by these structures, one can assume that the probability of a ship specifically colliding with a platform is lower.

In this respect, the expert opinions on the analysis of the behaviour of the support structures in the case of a collision must include a comprehensive treatment of a collision of a ship with an offshore station, but may also consider modified requirements. In particular, in consideration of the above mentioned criteria and requirements, the extent to which the platform has been designed to make it as “collision friendly” as possible must be accordingly demonstrated. In those cases in which the danger to ships, safety or the marine environment has been classified “Significant”, specific alternatives shall be additionally assessed and represented in order to minimise the hazards to ships, safety and the marine environment.

* Based on the acceptance criteria with regard to the readiness for approval of offshore wind farms fixed by the BMVI working group “Approval-relevant Recommended Guidelines” (not more than one collision cumulated within 100 years), it can be assumed that, for the analysis of the behaviour of the wind turbine in the case of a collision, the probability of occurrence of a collision classified “Occasional” and “Frequent” is not admissible and therefore not significant in practice.

Appendix 2 Individual Technical Approval

Appendix 2-I General procedure

2-I.1 Fundamentals

2-I.1.1 Requirements of an individual Technical Approval

German Building Law distinguishes between regulated and non-regulated construction products or types of construction. For the use of non-regulated construction products or types of construction within the Exclusive Economic Zone (EEZ), an individual Technical Approval shall be obtained from the BSH, which is the competent approval authority, whereby the individual Technical Approval is the proof of the usability, resp. applicability of the subject matter of the application.

The applicant is obliged to specify non-regulated construction products and types of construction. An individual Technical Approval does not replace any structural tests that may be required and which shall be carried out by the certified inspector.

Within the framework of the same project, different types of construction, for example wind turbines and substations, shall be considered independent subject matters.

2-I.1.2 Application for an individual Technical Approval

An individual Technical Approval is granted at project-level. An application for an individual Technical Approval may only be submitted for the use, resp. application, of a specific non-regulated construction product or a specific non-regulated type of construction in a specific construction project.

2-I.2 General process

The builder of the structure or his/her nominated deputy shall apply for the individual Technical Approval ad hoc at the BSH. To this purpose, he/she shall use the services of a suitable expert who is a competent assessor for the approval object. This expert has the following tasks and responsibilities:

Step 1
Compilation of a concept paper with regard to the planned procedure in order to demonstrate the subject matter of the application. As a rule, this shall at least contain:

- A detailed description of the subject matter of the application. The non-regulated construction product, resp. the non-regulated type of construction, shall be outlined in detail.
- A detailed description of the requirements placed on the subject matter of the application that are considered as being significant. It may be necessary to provide references to the technical codes of practice introduced by the construction authorities relevant to the object being examined – and where this object differs from such codes of practice.
- A topically complete but short presentation of the planned concept of investigation and demonstration to be used for obtaining the individual Technical Approval.
- In order to reliably assess the list of requirements and the complexity of inspection for the individual Technical Approval, the project shall be coordinated at an early stage with the assessor, the appointed inspector, the BSH and the BAM.

Step 2
Presentation of an independent expert opinion in order to prove that all the requirements have been met. The assessor shall provide a reliable and unambiguous statement as to whether, from his/her technical point of view, an individual Technical Approval can be recommended.

Depending on the subject matter of the application, it is possible to waive this two-step procedure, if the assessor submits a respective application in agreement with the BSH. In this case, the entire set of application documents, in combination with the expert opinion and a confirmation that all the requirements have been met, shall be submitted.

2-I.3 Miscellaneous

It is recommended to initiate the procedure for the individual Technical Approval at an early planning stage in order to be able to draw up and present the necessary documents in good time. As experience has shown, required expert opinions demand a huge amount of time.

2-I.4 Time schedule

In general, the individual Technical Approval must be available for the 3rd release.

The expert opinion, including all the requirements placed on the use of the subject matter of the application, shall be submitted to the BSH prior to the 2nd release. A reliable statement from the assessor with respect to specific design questions may also be required in order to complete the basic design (final design). This shall also be submitted to the BSH prior to the 2nd release.

Proof that all the requirements of the expert opinion have been accordingly met shall be available for the 3rd release, at the latest two months prior to the construction product/type of construction under review in these proceedings being used for the first time.

2.-I.5 Simplified procedure for Individual technical Approvals

For construction products and types of construction for which an individual Technical Approval has already been obtained during other proceedings, the assessor may come to an agreement with the BSH regarding the necessity of a complete concept by referring to the individual Technical Approval already granted.

Appendix 2-II Special notes for procedures related to grouted joints

2-II.1 Fundamentals

In terms of the European Construction Products Directive, grouted joints represent an non-regulated type of construction; therefore, the mortars and concrete (grout) implemented represent non-regulated construction products.

2-II.2 General procedure

The builder of the structure, resp. his/her nominated deputy, shall apply ad hoc for the individual Technical Approval at the BSH. To this purpose, he/she shall use the services of a suitable expert who is a competent assessor for the approval object. This expert has the following tasks and responsibilities:

Step 1
Compilation of a concept paper with regard to the planned procedure in order to demonstrate the grouted joint. This shall at least contain:

- A detailed description of the subject matter of the application. The construction products that are planned to be used in coordination with the contractor shall be outlined in detail.
- An exact description of the requirements placed on the grouted joint that are considered as being significant. It may be necessary to provide references to the technical codes of practice introduced by the construction authorities relevant to the object being examined – and where this object differs from such codes of practice
- A topically complete but short presentation of the planned concept of investigation and demonstration to be used for obtaining the individual Technical Approval.

In order to reliably assess the list of requirements and the complexity of inspection for the individual Technical Approval, the project shall be coordinated at an early stage with the assessor, the appointed inspector, the BSH and the BAM.

Step 2
Presentation of an independent expert opinion. Once proof that all the requirements have been met has been provided, the assessor shall issue a reliable statement as to whether, from his/her technical point of view, an individual Technical Approval can be recommended.

2-II.3 Technical notes

The technical assessment shall be conducted by the assessor appointed by the builder of the structure. This assessment is the sole responsibility of the assessor.

The following questions shall be addressed:

- Definition of the required performance characteristics of the material and the consequent requirements and test methods, resp. procedures to be used (e. g. temperature and time-dependent characteristics of fresh grout, shrinkage, durability with respect to mechanical, dynamic and climatic stress).
- Presentation and, if required, assessment (comparative computation) of the verification methods and processes.
- Description of the requirements placed on the implementation.
- Description of the safe application at the structure, and, if required, proof that the grouting has been accordingly completed and displays the required properties.
- Definition of the quality assurance requirements, both in the factory and at the construction site, with respect to in-house and external monitoring.
- As the deployed materials represent non-regulated construction products used in stability-relevant applications, a 1+-rated proof of conformity analogous to that used in the verification system implemented by the European standards for construction products is required. The respective characteristics shall be developed by the assessor.
- Regarding the monitoring of the implementation at the offshore construction site, the requirements shall be fulfilled to monitoring class 3 standards – analogous to DIN 1045-3 – as particularly difficult conditions of implementation are involved that are not reversible in the case of an application error.
- Furthermore, the finish of the planned materials shall also be classified with a view to their sensitivity to extraneous influences.
- A concept for the procedure to be applied in the case of unscheduled production, e. g. repair grout.
- A concept for the performance of periodic inspections according to this standard and, if required, supplementary monitoring measures.

Appendix 3 Application notes for geotechnical verifications

Appendix 3-I Consideration of cyclic loads in the design of foundation elements

3-I.1 Preliminary remarks

With all foundation types presently considered, cyclic loads acting on the foundation elements and conducted into the foundation soil reduce the bearing capacity of the foundation and lead to accumulated deformation. Depending on local conditions, unfavourable changes of pore water pressure are possible which may lead to soil liquefaction.

To assess possible changes of the bearing capacity of foundation elements, a planning expert and a geotechnical expert with special knowledge in this particular field shall be commissioned.

Within the scope of the obtaining the 1st release from the BSH, the concept for incorporating cyclic loading in the design of foundation elements for the supporting structure and an explanation of the inspection programme planned to be carried out have to be provided.

As part of the 2nd release process, verification has to be provided that cyclical loading has been taken into account, which includes the documentation of laboratory and field tests conducted in that context.

3-I.2 Cyclic loads on offshore wind turbines

3-I.2.1 Design event

The foundations of offshore wind turbines are continually subject to the non-static impacts of wind, waves and operation loads acting on the support structure. To establish the loads on the support structure of the wind turbine, please refer to chapter B3.3.1.2. Cyclic loading has to be included in the verification of bearing capacity by calculating a storm event as described in the following, also taking into account the other load cases. A special operating condition causing major cyclic loading of the foundation elements may also have to be included in the calculations.

The potential bearing capacity reduction of a foundation which is subject to cyclic loading during a major storm event (please refer to Table 3-I.1 and Figure 3-I.1), has to be analysed taking into account the complete load spectrum. The storm event shall include the design extreme value acting on the foundation elements, and the number and distribution of extreme values used must be typical of the particular site. The loads thus computed shall be converted to the maximum design loads (please also refer to DIN EN 61400-1, Annex F).

The design event used to verify bearing stability under cyclic loading is described on the basis of the definition of design load case DLC 6.1 described in DIN EN 61400-3 and the boundary conditions indicated in Table 3-I.1.

DLC 6.1: Parking – idling, EWM & H_s50 yaw error = +/-8°	
Wind model	Turbulent wind model (EWM)
Wind speed (m/s)	V50, 1h
Intensity of turbulence	12%
Wind direction	0 degrees
Yaw angle	-8, 0. 8 at the beginning of the computation
Wave direction	0 degrees

Table 3-I.1: Load case definitions

The standardised curves of wind speed and significant wave height are shown as dashed lines in Figure 3-I.1. They are defined as follows:

- Wave height: max. H_S over a period of three hours, linear decrease to 0.5 H_S after ±17.5 hours.
- Wind speed (recommendation according to EU project RECOFF)

  $v(t) = 1 – 0{,}09\ (t/10)^{0{,}45}$ with t = Zeit in [min] {-1.050 min ≤ t ≤ +1.050 min}

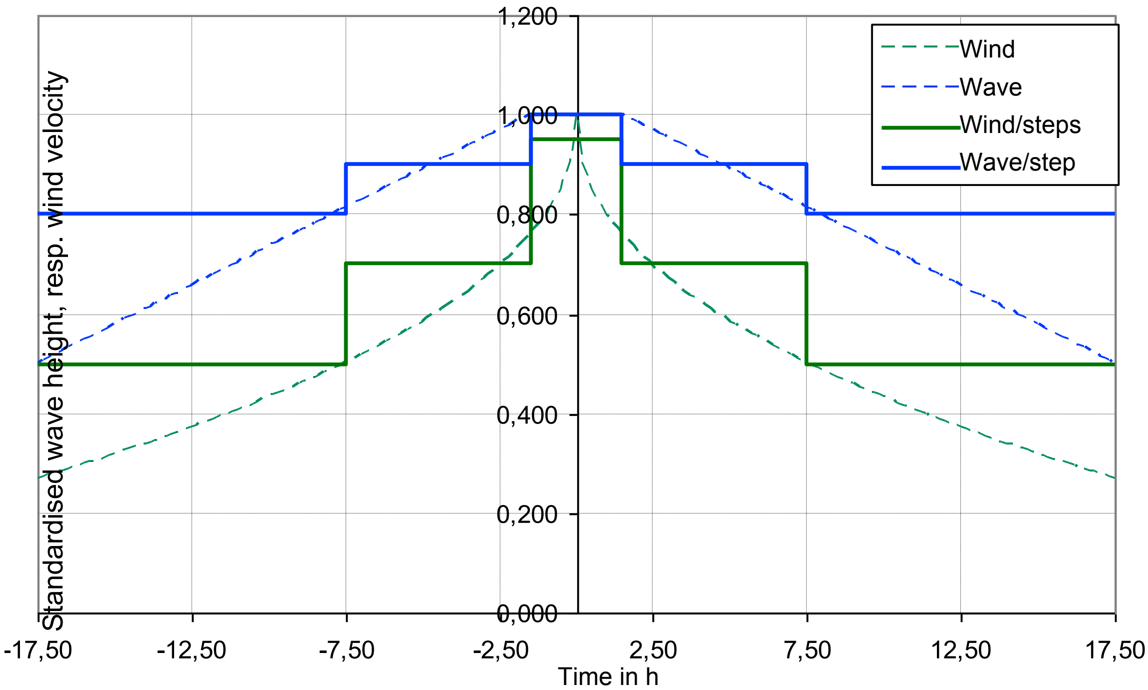


Figure 3-I.1 Development of wind speed and the significant wave height during the design event.

In order to verify sustainability, all potential reductions of sustainability due to the design event shall be taken into account. As all design loads are taken into consideration, the unique design storm is currently considered as being sufficient for the design. Accordingly, no further storm events need to be included with respect to verifying sustainability.

3-I.2.2 Equivalent load spectrum

In order to assess the impacts of loads of different amplitudes and, possibly, varying directions, it may be appropriate to derive a cyclic equivalent load (equivalent single-stage spectrum) from the design event load. The cyclic equivalent load should comprise a mean load level Fmitt, a load amplitude Fampl and an equivalent number of load cycles Neq (please refer to Figure 3 I.2).

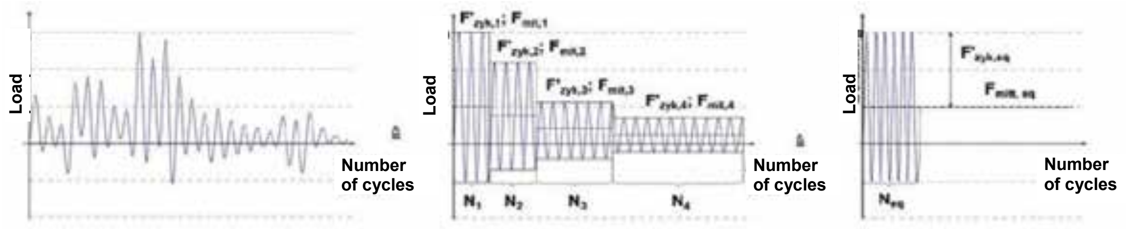


Figure 3-I.2 Definition of the equivalent number of load cycles and load amplitude (please compare with EA-Pfähle)

The establishment of the equivalent single-stage spectrum shall be undertaken in consideration of the selected verification process as well as the boundary conditions specific to the location and the foundation element, whereby the appropriateness of this simplification shall be accordingly represented. Chapter 13 of EA-Pfähle contains information on the practical application in the case of piles.

3.I-2.3 Loading conditions, design situations and respective partial safety factors

Impact combinations are attributed to geotechnical design situations according to DIN 1054. The design load values are determined in analogy to the DIBt guideline for wind turbines, with partial safety factors deviating from those mentioned in DIN 1054.

The partial safety factors for impacts can be derived from the standards and guidelines for offshore wind turbines referred to in B3.3.1. The BSH reserves the right to grant its consent. To assess the impacts of cyclic loads on the foundation elements, the characteristic impact loads normally have to be indicated.

3-I.3 Cyclic loads on offshore platforms

For any investigation of the influence of cyclic loads on the stability of the foundation elements of shallow foundations and special platform foundations similar to shallow foundations (e.g. suction caisson foundations), loads shall be calculated for a 100 year cycle.

For deep foundations, the necessity of an explicit mathematical consideration of the cyclic loads in the verification control process can be assessed by means of a simplified marginal value analysis of the load range, resp. load amplitudes, according to the criteria described in EA-Pfähle. For this, the load shall be the maximum load induced by waves within a 50 year cycle (H_{max50}). The action of the current shall be superimposed on this in an adverse fashion (possibly in opposite directions). If the explicit mathematical consideration of the cyclic loads is required for the verification control process, the decisive load spectrum shall be determined by means of a design storm. In the case of deep foundations, loads shall be calculated for a 50 year cycle.

<u>Note:</u>
For verifications concerning the cyclic loads pertaining to deep foundations that are mainly subject to axial loading, it is sufficient to calculate loads for a 50 year cycle:

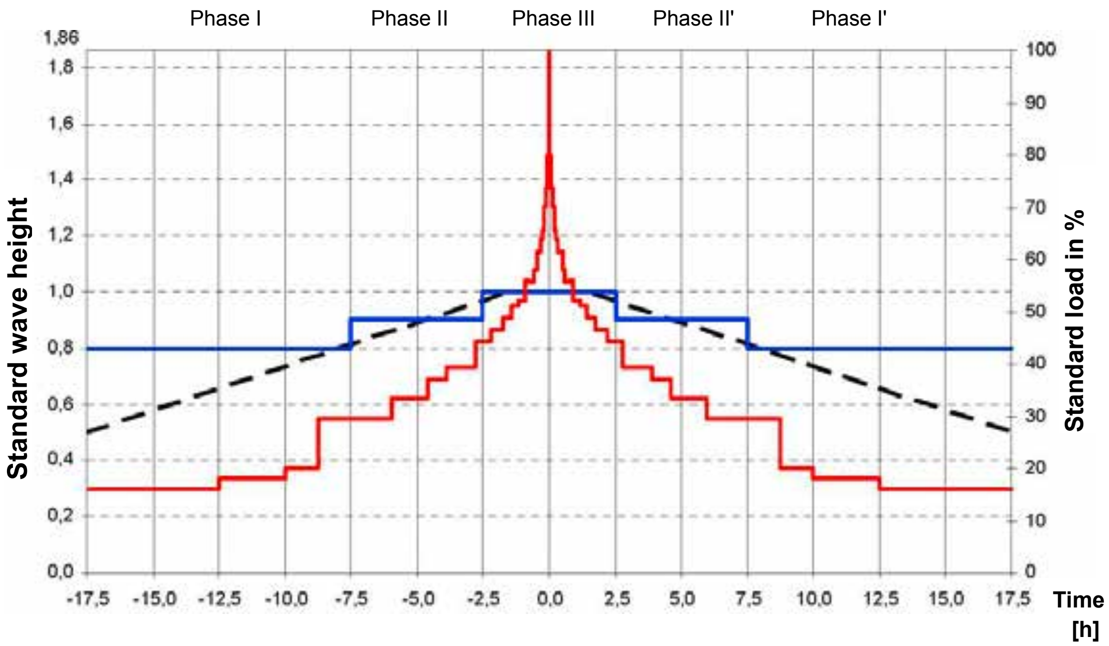
- Both in the case of a simplified marginal value analysis of the load range, resp. the load amplitudes, according to the criteria described in EA-Pfähle as a result of the limiting value criterion: $F'_{zyk} < 10\%$ of $R_{k,}$
- As well as in an explicit verification control process because the loads during the 100 year cycle would otherwise be considered twofold, namely first in the form of a degradation of the deep foundation and then as a decisive effect within the scope of the verification control process.

In the case of the verification control process for heavyweight foundations, this is different in so far as the extreme event is only considered once in the verification control process. In this connection, the reduction of the shear strength as a result of the accumulation of pore water pressure during the design storm shall be determined. The load spectrum shall then be accordingly verified.

The determination of the wave distribution during the design storm (wave height and period with the respective number of cycles) is conducted using statistical extreme value distributions (e. g. Rayleigh distributions). A stress spectrum that is appropriately quantified for foundation elements can be determined by establishing the chronological progression of the foundation loads for the varying wave heights between the phases of significant wave height at the beginning and the end of the storm, and the maximum wave height during the strong wind phase. For offshore stations, a five-hour strong wind phase shall be considered, whereby the ULS incident is to be integrated into the stress spectrum of the design storm.

In order to establish the wave distribution and achieve a simplified determination of the stress spectrum, the distribution according to *Hansteen* may be consulted for locations in the North Sea as represented by *Andersen* [1]. The result of transferring a *Hansteen* distribution related to a five-hour strong wind phase (Table 1) to a five-phase storm event of 35 hours duration according to [1] is, in the case of an ascending and descending arrangement of the standardised wave heights that are determined for each of the phases of storm, a distribution of the standardised wave height and the load on the foundation elements that is standardised with regard to the extreme load as it is shown in Figure 3-I.3. The standardised wave height is the ratio of the wave height to the significant wave height during the strong wind phase.

For further information, please refer to *Andersen* [1].



– – Standardised wave height
— Discretisation of the standardised wave height
— Distribution of the standardised wave and foundation load (quantified approach of the standardised wave height, combined phase by phase with the Hansteen distribution and subsequently rearranged)

Figure 3-1.3: Wave distribution and standardised foundation loads induced by the wave load, for a 100-year design storm, incl. a five-hour strong wind phase and segmentation into five storm phases.

Cycles during the strong wind phase (5 h)	Total number of cycles	Standardised load on the foundation elements according to [1].	Standardised wave height during the strong wind phase in [1}
900	900	0.20	0.37
500	1,400	0.37	0.69
200	1,600	0.49	0.91
90	1,690	0.58	1.08
50	1,740	0.64	1.19
30	1,770	0.70	1.3
15	1,785	0.77	1.43
8	1,793	0.82	1.53
4	1,797	0.89	1.66
2	1,799	0.96	1.79
1	1,800	1.0	1.86

Table 3-I.2 Standardised load on the foundation elements and standardised wave height according to the Hansteen distribution for the strong wind phase (-2.5 h to +2.5 h)

[1] Andersen K.H.: Foundation design of offshore gravity structures; Publication No. 185, Norwegian Geotechnical Institute, Oslo 1992

3-I.4 Cyclic loads on measurement masts, cable towers and comparable structures

The design of the foundation elements of measurement masts, cable towers and comparable structures with respect to cyclic loads shall be addressed according to their respective construction types and stress spectrums and in accordance with the requirements and regulations specified in sections 3-I.2 and 3-I.3.

Appendix 3-II Verification of the limit states for foundation elements taking into account cyclic loading

3-II.1 Preliminary remarks

Ultimate limit states of bearing capacity and serviceability taking into account cyclic loading effects have to be calculated both for shallow and deep foundations of offshore wind turbines. Based on general experience gained so far and, alternatively, the state of current scientific and technical progress, the following information is provided on the verification methods to be used.

In as far as cyclic laboratory tests are conducted to obtain the verification, these shall be planned and conducted in close consultation between the geotechnical expert and the author of the foundation design. Appropriate documentation is part of the verification documentation required for the final design for the 2nd release. For further information on cyclic laboratory tests, please refer to *Standard Ground Investigations.*

3-II.2 Shallow foundations (heavyweight foundations)

To verify the load bearing capacity of shallow foundations using conventional geotechnical methods, the decrease in load bearing capacity can be evaluated in a simplified manner by means of cyclic shear tests on undrained soil samples (e.g. using the cyclic triaxial test device; please also refer to *Savidis & Schuppe, 1982*).

Verification of the serviceability of shallow foundations can be conducted in observance of the recommendations provided in chapter E4 of the directive “*Subsoil Dynamics*” published by the DGGT study group 1.4. The examples provided herein can be applied to the shallow foundations of offshore wind turbines.

Further to the basic design rules set out in DIN EN 1997 (EC 7-1) and DIN 1054, steps shall be taken to ensure that soil erosion below the foundation due to cyclic loading is prevented. With respect to shallow foundations with no circumferential skirts of adequate penetration depth, this normally means that gap formation must be prevented – even where typical and continual loads are combined with variable loads in the most unfavourable combination possible.

3-II.3 Pile foundations

3-II.3.1 Axial cyclic loading

For verification processes and formats, please refer to *EA-Pfähle*.
Please note that the processes mentioned herein have initially only been tested within the framework of research projects and that these have been partially calibrated to model and large scale tests. Project-related application experience is not yet available.

3-II.3.2 Cyclic loading transverse to the pile axis

Lateral cyclic loading of pile foundations leads to a deflection of the pile head which, if large enough, places considerable stress on the soil close to the pile head, with pile deflection increasing with the number of load cycles. Also, bedding resistance (bedding capacity and bedding stiffness) may be reduced, if cyclic loading causes an accumulation of pore water excess pressure.

Moreover, in cohesive soils under water, permanent soil deformation may cause gap formation between pile and soil, and a destabilisation of the near-surface area, which reduces the bearing capacity of laterally loaded piles.

Notes on the assessment of the serviceability of piles that are mainly loaded transverse to the pile axis can be found in *EA-Pfähle*.

In order to verify the ultimate limit state for the lateral bearing capacity of a pile, it is necessary to determine the expected reduction of mobilisable bedding resistance taking into account the pile system used (type, diameter), type of soil and number of load cycles. The assessment can be made either on the basis of experience or can be based on the results of suitable cyclic laboratory tests taking into account changes of pore water pressure. Bearing capacity can be verified on the basis of bedding resistance, which may be diminished, applying the method described in chapter 13 of *EA Pfähle*, and using the "*p-y method*". In verifying serviceability and load capacity, application areas and limits of the methods chosen shall be taken into account.

The influence of changes of pore water pressure on the load bearing capacity shall be examined and taken into account, where applicable.

Appendix 3-III Dynamic pile load tests

According to DIN EN 1997- (EC 7-1) and DIN 1054, the external axial bearing capacity of foundation piles is verified by means of pile load tests. Therefore, dynamic pile load tests are required to verify the bearing capacity of offshore wind turbine foundations, where piles are predominantly subject to axial loading.

DIN EN 1997-1 (EC 7-1) and DIN 1054, with reference to *EA-Pfähle*, describe the methods to be used in conducting dynamic pile load tests and evaluating and interpreting the results. The geotechnical planning expert shall determine the number and the locations of the pile test loads to be conducted in accordance with *EA-Pfähle*. Generally, dynamic pile load tests shall be carried out at all offshore stations and at least 10 % of the offshore wind turbine locations, which should include at least two locations for each geotechnical location type found in the area of the wind farm.

The concept for the dynamic pile load tests (number, locations) shall be developed by the geotechnical planning expert and submitted with the application documents for the 2^{nd} release. The concept should specify the type and scope of tests to be carried out and the way in which the test results are to be applied to the entire construction site. The following documents are to be included: A report from the company conducting the dynamic pile load tests, incl. information on the planned sensors, their installation and the planned cable-laying procedure, as well as a confirmation with regard to the feasibility of the dynamic pile load tests compiled by the author of the design which gives consideration to all the relevant impacts on the foundation during the installation process (e. g. taking into account a cofferdam for installing the sensors and the laying of the cables).

Dynamic pile load tests are conducted during the first construction phase. The institutions commissioned to conduct the tests shall have proven experience in the field of dynamic pile load testing and test evaluation.

If the temporal development of the bearing capacity following installation of the piles is to be taken into account in the verification of bearing capacity, a sufficient number of additional piles shall be subsequently driven in as part of the dynamic pile load tests.

To derive characteristic pile resistance data R_k from the measurements of dynamic pile load tests R_m , the scatter factors defined in DIN 1054 have to be applied in accordance with DIN EN 1997-1 (EC 7). Where the supporting ground consists mainly of cohesionless soils, use of the scatter factors $\xi_{5,6}$ and $\Delta\xi$ in the case of "calibration of dynamic pile load tests against static pile load tests in similar construction measures" is allowed, even if static pile load tests have not been carried out at the particular construction site of the structure. This is due to the fact that ample experience with static and dynamic pile load tests in cohesionless soils is available from other construction projects in the entire area of northern Germany, and proven calibration factors thus are available for such soils. In addition, the pile foundations of offshore structures normally use steel piling, where scatter due to manufacturing is of lesser importance and where piling reports are prepared which allow a quantitative evaluation of each individual pile.

The dynamic pile load tests have to be supervised and evaluated by the responsible geotechnical expert. The complete documentation of the dynamic pile load tests conducted and of their evaluation and interpretation, as well as the geotechnical expert's translation of the results to the piles which have not been tested, shall be submitted to the BSH immediately after completion of the dynamic pile load tests and their interpretation.

The BSH, supported by expert advice, holds the view that dynamic pile load tests to determine axial bearing capacity currently are not required for the verification of monopile bearing capacity. Generally, measurements may be useful during piling operations in order to check pile drivability and driving stresses and to calculate the driving stresses exerted on the pile during pile driving. The BSH reserves the right to require monopiles to be subjected to dynamic pile testing for technical reasons or on the basis of recent findings.

Appendix 3-IV Use of the observation method according to Eurocode 7

The observation method in accordance with DIN EN 1997 (EC 7) is provided as a method for verifying stability against collapse. This method is a combination of normal inspections and verifications (forecasts) by means of ongoing measuring inspections of the structure, whereby critical situations are controlled by using suitable prepared technical measures. This method represents the recognised state of the art for structures the foundation design of which is not based on secure engineering experience. The observation period shall be extended to include the operating phase. Limit states that can neither be calculated with sufficient accuracy nor recognised in good time through observation shall be avoided by working on the safe side and through design measures. Where possible, mathematical forecasts shall be supplemented by experience gained through comparable construction projects. The following preparations shall be made prior to the start of construction in order to use the observation method:

- The limits of structural and ground behaviour to be maintained shall be defined.
- The area in which the structural behaviour will probably take place shall be ascertained based on existing survey results.

- It shall be demonstrated that the structural behaviour shall stay within the limits to be maintained, with an adequate degree of probability.
- The stability and serviceability limits to be complied with shall be accordingly differentiated.
- A measuring programme shall be prepared using significant parameters to check whether the actual structural behaviour is within the limits that are to be maintained.
- The critical values and intervention levels of the parameters acting as indicators of the limits to be complied with shall be accordingly determined.
- A plan of suitable countermeasures shall be developed for every possible eventuality in which measurements indicate that limits to be maintained have been exceeded. This plan forms part of the stability verification documentation. It shall be possible to execute the planned countermeasures at any time.
- The measuring intervals and results shall be capable of indicating the need for countermeasures at a sufficiently early stage for the countermeasures to be taken in good time.
- During construction work and operation, the measurement programme and its timely evaluation shall be carried out as scheduled and shall be documented. Deviations from this plan shall be documented.

Simply monitoring the structure without a detailed definition of the limits or counter measures is not suitable for the verification process.

Appendix 3-V Application of numerical models for geotechnical verifications

Preparing stability verifications using numerical methods in geotechnology is not generally the recognised state of the art in Germany. However, this is generally permissible according to DIN 1054. Basic modules for standardised approaches have been worked out in the form of recommendations by the *AK 1.6 Numerics in Geotechnics* study group at the German Geotechnical Society (DGGT).

Soil-mechanical model computations generally contain uncertainties. Although numerical models using the finite element method make it possible to use the continuum mechanical calculation models on complex structures even when taking account of the ground, these are extremely simplified and require critical assessment by the geotechnical planning expert.

Special ground properties, interactive processes and complex procedures can be studied in principle and qualitatively using numerical models, however quantitative studies cannot necessarily be reproduced or represented reliably. System changes due to cyclical processes cannot generally be represented with sufficient reliability.

Plausibility checks represent a significant element in assessing numerical calculation results, e. g. by comparing them with areas of experience. Where adequate experience with foundations for comparable offshore structures is not available, particular value shall be placed on formulating simple analytical models and on making a critical and cautious evaluation of the results when designing the foundation elements and assessing their interaction with the support structure. This includes a sensitivity analysis with respect to the decisive model parameters.

Appendix 3-VI Special references for foundation elements

BSH — Standard Ground Investigations – Minimum requirements for geotechnical surveys and investigations into offshore wind energy structures, offshore stations and power cables (in the respective valid version).

DIN EN 1997-1 — Eurocode 7: Geotechnical design – Part 1: General rules; German version EN 1997-1

DIN EN 1997-1/NA — National Annex – Nationally determined parameters – Eurocode 7: Geotechnical design Part 1: General rules

DIN 1054 — Subsoil – Verification of the safety of earthworks and foundations – Supplementary rules to DIN EN 1997-1. German version.

GL-IV-2 — GL Rules and Guidelines, IV Industrial Services, 2 Guideline for the Certification of Offshore Wind Turbines

DNV-OS-J101 — DNV Offshore Standard – Design of Offshore Wind Turbine Structures

DIBt — DIBt guideline for wind turbines – Actions on and verification of stability against collapse for tower and foundation, DIBt Berlin, German version.

API RP 2A-WSD — American Petroleum Institute – Recommended Practice – Planning, Designing, and Constructing Fixed Offshore Platforms – Working Stress Design, 21st Edition, December 1993.

Norsok N-003 — Actions and actions effects. Rev. 2, Sept. 2007

EA-Pfähle — Recommendations of the study group “Piles”, 2nd supplemented and enlarged edition, DGGT e.V., Verlag Ernst & Sohn, 2012). German version.

RECOFF — Recommendations for design of offshore wind turbines (RECOFF), European Community (contract No. ENK5-CT-2000-00322, acronym RECOFF) under the Energy, Environment and Sustainable Development Programme, a Fifth Framework Programme, 2001–2004, Risoe, 2007

Achmus, M., Kuo, Y.-S., Abdel-Rahman, K. (2008): About the design of monopiles for cyclic loads *(Zur Bemessung von Monopiles für zyklische Lasten)*, Bauingenieur, Volume 83 (7–8), pp. 303–311. German version.

Atkins, W.S. (2000): Cyclic degradation of offshore piles – Offshore Technology Report 2000/013, HSE Health and Safety Executive, Norwich, UK.

Cuellar, R (2011): Pile Foundations for Offshore Wind Turbines: Numerical and experimental investigations on the behaviour under short-term and long-term cyclic loading, Dissertation TU Berlin.

Cuellar, R, Baessler, M., Rücker, W. (2009): Ratcheting convective cells of sand grains around offshore piles under cyclic lateral loads, Granular Matter (2009), 11, pp. 379–390.

Grabe, J., Dührkop, J. (2008): About the load bearing performance of mainly horizontally loaded piles *(Zum Tragverhalten von überwiegend horizontal belasteten Pfählen)*, Conference proceedings, 30th Baugrundtagung, 2008, DGGT, Dortmund, pp. 143–150. German version.

Jardine, R., Standing, J.R. (2000): Pile Load Testing Performed for HSE Cyclic Loading Study at Dunkirk, France. Offshore Technology Report – OTO 2000 007. Vol. 1.

Kempfert, H.-G., Thomas, S. (2010): Load bearing performance of piles due to cyclic loads – Test results and modelling – *(Pfahltragverhalten infolge zyklisch axialer Belastung – Versuchsergebnisse und Modellbildung)*. German version. Conference proceedings to the 31st Baugrundtagung, 2010, DGGT, Munich, pp. 255–261.

Poulos, H.G. (1989): Cyclic Axial Loading Analysis of Piles in Sand. Journal of Geotechnical Engineering, American Society of Civil Engineers, 115, pp. 836–852.

Randolph, M. F. (2009a): Cyclic interface tests on sand and influence of cyclic shearing on axial pile capacity in sand. In: Mechanical behaviour of soils under environmentally induced cyclic loads. International Centre for Mechanical Sciences (CISM): Udine, Italy.

Randolph, M. F. (2009b): Offshore Design Approaches for Sub-Failure Cyclic Loading of Foundations. In: Mechanical behaviour of soils under environmentally induced cyclic loads. International Centre for Mechanical Sciences (CISM): Udine, Italy.

Randolph, M. F. Jeer, H. A., Khorshid, M. S. and Hyden, A. M. (1996): Field and laboratory data from pile load tests in calcareous soil. Proceedings of the 28th Offshore Technology Conference, Houston, Texas, pp. 327-336.

Savidis, S., Schuppe, R. (1982): Dynamic triaxial device for the investigation of the liquefaction behaviour of isotropic and anisotropic consolidated sands *(Dynamisches Triaxialgerät zur Untersuchung des Verflüssigungsverhaltens von isotrop und anisotrop konsolidierten Sanden)*, Bautechnik, Vol. 1, 1982, pp. 21–24.

Tasan, E., Rackwitz, F., Savidis, S. (2010): Accumulation of pore pressures at cyclic horizontally loaded monopiles with large diameters *(Porenwasserdruckakkumulation bei zyklisch horizontal belasteten Monopiles mit großen Durchmessern)*, Bautechnik, Vol. 8, 1987, pp. 449–461.

Appendix 4 Amendments to the verifications in the Fatigue Limit State for offshore wind turbines

Until the introduction of national regulations by means of a DIN standard or an appropriate European standard, the values indicated in the following table, in combination with the regulations of the current Directive for Wind Turbines concerning the partial safety factor γ_M for materials, are to be considered as minimum values for establishing a verification in the fatigue limit state.

Verifiable	Damage-Tolerant Components	Non-Damage-Tolerant Components
Yes	1,0	1.15
No*	1.15	1.25

* Welded constructions of the primary support structure that are situated under water must always be classified "No".

In order to demonstrate fatigue according to DIN EN 1993-1-9, offshore-specific amendments may be necessary. Amendments may be required, in particular, for the number of anticipated load changes and in order to handle seawater. To this purpose, appropriate directives and codes of practice shall be consulted.

Regarding the selection of material quality, please refer to the notes in Appendix 5.

Note with respect to periodic inspections:

This regulation does not replace the need for periodic inspections in the underwater area (e.g. to inspect growth and damage). However, this renders a detailed inspection of the weld seams dispensable.

Appendix 5 Application notes for the BSH Standard Design – “Minimum requirements concerning the constructive design of offshore structures within the Exclusive Economic Zone (EEZ)”

Notes on the verifications of stability against collapse for support structures of offshore stations and the choice of steel grade

Appendix 5-I Reason and purpose

chapter B2.3 Design phase, sub-chapter B2.3.2 specifies the requirements and necessary verifications which shall be provided as part of the structural design.

It states that substructures of offshore stations shall be designed and dimensioned uniformly on the basis of the DIN EN 199x series of European standards. The special features of the design and the operating conditions in the marine environment mean that different, additional aspects have to be taken into account here, for which the above-mentioned series of standards sometimes does not contain adequate regulations at present.

When the standards are to be used in the EEZ, the following application notes provide corresponding, additional or more specific content for the regulations which allow DIN EN 199x (EC series) to be used throughout the verification procedure. The application notes, therefore, represent the operational framework for designs and inspections in application procedures. In particular, the technical construction standards introduced and the Building Rules List are extended with more detail by regulations which, when complied with, obviate the need to apply for an individual Technical Approval.

These application notes represent a temporary regulation and as such define minimum standards which the project must meet. More stringent requirements in respect of the dimensioning and design are sometimes usual and expressly permissible.

The notes relate to the actions, safety margins in general, and the design of steel structures.

Appendix 5-II Normative references

[1] DIN EN 1990 “Eurocode 0: Basis of structural design”

[2 DIN EN 1990/NA: 2010-12: National Annex – Nationally determined parameters – „Eurocode 0: Basis of structural design”

[3] DIN EN 1991: “Eurocode 1: Actions on structures”

[4] DIN EN 1991/NA: National Annex – Nationally determined parameters – “Eurocode 1: Actions on structures, issue 2010/12”

[5] DIN EN 1993-1-1: “Eurocode 3: Design of steel structures – Part 1-1: General rules and rules for buildings”; issue 12/2010, incl. National Annex

[6] DIN EN 1993-1-9: “Eurocode 3: Design of steel structures – Part 1–9: Fatigue”; issue 12/2010, incl. National Annex

[7] DIN EN 1993-1-10: “Eurocode 3: Design of steel structures – Part 1–10: Material toughness and through-thickness properties”; issue 12/2010, incl. National Annex

[8] DIN EN 10025-1 to -4: “Hot rolled products of structural steels – Part 1–4”: issue 11/2004, German version prEN 10025-1:2011

[9] DIN EN 10204: “Metallic products – Types of inspection documents“; issue 01/2005

[10] DIN EN 10210-1: "Hot finished structural hollow sections of non-alloy and fine grain steels – Part 1: Technical delivery conditions"; issue 07/2006

[11] DIN EN 10219-1: "Cold formed welded structural hollow sections of non-alloy and fine grain steels – Part 1: Technical delivery conditions"; issue 07/2006

[12] DIN EN 10225 "Weldable structural steels for fixed offshore structures – Technical delivery conditions"; issue 10/2009

[13] DIN EN 61400-1 (VDE 0127-1): "Wind turbines - Part 1: Design requirements (IEC 61400 1:2005 + A1:2010)"; issue 08/2011, German version EN 61400-1:2005 + A1:2010

[14] DIN EN 61400-3 (VDE 0127-3): "Wind turbines – Part 3: Design requirements for offshore wind turbines (IEC 61400-3:2009)"; issue 01/2010, German version EN 61400-3:2009

[15] International Institute of Welding (IIW): "Recommendations for fatigue design of welded joints and components"; IIW-1823-07 ex XIII-2151-07/XV-1254-07; 2008 edition

[16] DIN EN 1090-2: "Execution of steel structures and aluminium structures – Part 2: Technical requirements for steel structures"

[17] DNVGL-RP-0005: "Fatigue design of offshore steel structures"; issue 06/2014

Appendix 5-III Verification states and actions

5-III.1 Verification methodology

The requirements and requisite verification states shall be taken from DIN EN 1990 [1], [2] and chapter B2.3.2.

5-III.2 Actions

The following notes on actions and their combinations refer to the design of the structure in its final state after all construction and installation states have been completed.

Actions or load assumptions shall generally be chosen in accordance with the DIN EN 1991 series of European standards.

Supplementary notes on actions, which result from gaps in and sensible additions to DIN EN 1991 [3], [4], are provided below.

Dead-weight and superimposed loads:

Actions resulting from dead-weight and superimposed loads shall be taken from the technical specifications of the DIN EN 1990 series.

It is recommended that the dead-weight and superimposed loads of the offshore stations considered here be determined by weighing them. In this case, $\gamma_F = 1.10$ may be used in the calculation.

Live loads:
Live loads are regulated in DIN EN 1991 [3], [4]. The values are to be applied to the rooms and corridors of an offshore station. Deviations are permissible in justified cases.

The loads may be reduced in conformance with the standards in order to verify the load-transferring components. The most unfavourable load positions shall be taken into account here (effective load positions).

Wind actions:

Wind actions can be obtained from DIN EN 1991 [3], [4]. If expert opinions for the sites are consulted to ascertain the wind speeds and the variations which actually occur in the area being planned, a cycle of 50 years and a gust wind speed as a 3-second average shall be assumed when evaluating or selecting the input values of the wind speed, in conformance with DIN EN 1991 [3], [4].

Actions caused by waves, water current, ice and temperature:

Wave, water current and ice loads (sea ice as well as frost formation) and thermal actions depend on the location. Thus, to determine the input data for the design, an assessor shall specify the site conditions for the expert opinion on the swell.

When evaluating the site conditions in respect of the wave, water current and ice loads in particular, the cycles (50 years) shall be used for offshore stations, in line with the specifications in the offshore wind sector ([13], [14]).

Water levels, especially minimum and maximum water levels, to determine the actions shall also form part of the expert opinion for the site.

Miscellaneous actions:

Actions, for example from impact and collision loads, lifting gear or other variable loads which are specific to the installation and operation of offshore stations, shall be specified by the builder of the structure.

Impact loads resulting from the impact of a ship or imperfections during the manufacture, installation and settling shall also be taken into account in the verification. They depend largely on the site.

Further actions or special states arising from the scouring of the ground, marine growth or thickness reduction through corrosion of the structures shall be taken into account in an appropriate way. Site-specific expert opinions may be required here.

5-III.3 Combinations of actions and partial safety factor

General procedure:
The principles of action combinations and action-related partial safety factors when designing the operational structure of offshore stations (topside) are regulated in DIN EN 1990 [1], [2].

Combination factors for the superposition of wave, water current and ice occurrences are not listed in DIN EN 1990. As an alternative to the undiminished superposition of the individual occurrences listed, actions from the combined occurrence of waves, water currents and ice with a 50-year cycle may be used in the estimate. In order to superimpose the individual actions as per DIN EN 1990 [1], [2] by means of leading and accompanying actions, it is necessary to ensure that an integral, action-related partial safety factor of at least 1.35 is adhered to for the normal or extreme action combination.

Appendix 5-IV Application notes on DIN EN 1993-1-9 – fatigue verifications

5-IV.1 General information and partial safety factors

The verifications in the fatigue limit state shall always be conducted according to DIN EN 1993-1-9 [6] using either the nominal stress concept or the structural stress concept. Which concept is used – damage tolerance or adequate safety margin against fatigue failure without any prior indication – depends particularly on the feasibility of planned periodic inspections. The partial safety factors γ_{Mf} shall be selected accordingly along the lines of [6] from Table 5-IV.1.

Accessibility/execution of periodic inspections	Damage tolerant or minor damage	Not tolerant to damage or major damage
Good accessibility, periodic inspections	1.00	1.15
No or poor accessibility, no periodic inspections*	1.15	1.35

* It shall be assumed that the accessibility to all components which are permanently under water is poor, for example.

Table 5-IV.1: Partial safety factors in the fatigue verification

Contrary to what is stated in the regulations in [6], a threshold value for the fatigue strength shall not be used when the number of load cycles $N > 10^8$.

In contrast to what is stated in [6], the recommendations of IIW [15] Section 3.5.2.1. state that the dependence of the fatigue strength on effects of the metal sheet thickness should be taken into account.

Using the notch detail definitions according to [6] assumes that all components have a functioning corrosion protection system. The requirements in accordance with chapters B2.2.1, B2.3.1 and Annex 6 shall be complied with in this case. Depending on the achievable lifetime of the corrosion protection, the design shall include allowances to the calculated metal sheet thicknesses in the vicinity of the splash zone.

In addition, the regulations of DNV [17] may be used for the fatigue verification. This can be particularly useful when there is no comprehensive corrosion protection as stated above and the correspondingly modified stress number curves are used.

5-IV.2 Structural stress concept

The fatigue verifications for welded nodes of hollow sections can be conducted solely according to the structural stress concept. The stress concentration factors required for this shall be determined separately for all verification points with the aid of finite element calculations or from parametric equations. Relevant notes, e.g. [15] Section 2.2.3.4, can be obtained to extrapolate the stresses from FE calculations. When parametric equations, e. g. as developed by Efthymiou, are used, it is necessary to ensure that the geometric boundary conditions are precisely adhered to, an FE calculation should be preferred in cases of doubt.

The above-stated notes for nodes of hollow sections shall apply similarly to other constructional details.

The structural stress concepts can be used only for a seam which is welded on both sides. An application shall be made to the appointed inspector to use single-sided welds at nodes of hollow sections in an individual case and the procedure shall be agreed. Depending on the stress state and the possibility of carrying out non-destructive tests, consideration can also be given to using the structural stress concept for single-sided welds.

Appendix 5-V Application notes for DIN EN 1993-1-10 – choice of steel grades

5-V.1 Material standards and ordering

The steels to be used shall always be ordered according to the steel grades listed in DIN EN 1993-1-1 [5] Table 3.1 and corresponding material standards.

If the steel grade selected in accordance with DIN 1993-1-10 [7] is outside the regulated range, for example when greater metal sheet thicknesses are used and/or at low service temperatures, additional steel grades and the associated material standards shall be used. In this case, the use of steels in accordance with DIN EN 10225 [12] is permissible. Since the steels in accordance with DIN EN 10225 [12] are semi-finished products which are not part of the Building Rules List, the quality and test specifications of DIN EN 10025-1,-3,-4 for sheet steel and DIN EN 10210-1 for hot-formed hollow sections shall be used if they contain more stringent requirements than DIN EN 10225. Steels of group 1 in accordance with DIN EN 10225 are excluded from this.

For all products which are predominantly stressed when not at rest, acceptance test certificates 3.2 in accordance with DIN EN 10204 [9] shall be available for each melt with the following additional information:

- 15 element analysis (chemical composition) – concentration of C, Mn, Si, S, P, Al, N, Cu, Cr, Nb, V, Ti, Mo, Ni, B
- AR state not permissible under dynamic load
- Marking of the authorised approval inspector

A permanent stamp is not permissible in dynamically loaded components.

5-V.2 Selection of steel grades paying due heed to fracture toughness

The regulations according to [7] Section 2 may be applied when selecting steel grades in accordance with standards [8], [10] to [12].

The following design situations must be considered:

$$E_{d1} = E \{ A[T_{Ed}] \text{ „+“ } \sum G_k \text{ „+“ } Q_{Ek} \} \text{ and } E_{d2} = E \{ A[T_{Ed}] \text{ „+“ } \sum G_k \text{ „+“ } A_k \}$$

The leading action A represents the effect of the reference temperature T_{Ed}. $\sum G_k$ is the sum of the permanent actions. QEk is the combined action from the ambient conditions, such as swell, wind and sea ice, with a cycle of 50 years. A_k is the action from the planned docking impact of a supply ship.

Contrary to the requirement in DIN EN 1993-1-10/NA [7], the service temperatures $T_{mdr} = T_{md} + \Delta T_r$ may be selected from the following table. The value given in line 1 also applies here to components where only one side is wetted by water if unobstructed ventilation is not possible on the side away from the water (e. g. inside the hollow sections of the foundations). If this is not the case, the value in line 3 shall be used in the calculation.

Line	Components or sections of the components of the foundations	Service temperature T_{mdr}
1	– below lowest astronomical tide (LAT)	-5 °C
2	– above lowest astronomical tide (LAT)	-15 °C
3	– which are permanently wetted by water from one side	-10 °C

Table 5-V.1: Service temperature for components in the EEZ of the North Sea and the Baltic

For cold-formed circular hollow sections in accordance with DIN EN 10219 [11] where the ratio of the inner radius to the wall thickness $r_i/t \leq 15$, the steel grades used should be those for which sufficient Charpy impact energy values after strain aging have been verified. This can be done by ordering Option 12 for steel grades in accordance with DIN EN 10225. The temperature shift for the brittle fracture verification shall be determined using Equation 2.4 in accordance with DIN EN 1993-1-10 [7] and limited to a maximum $\Delta T_{\varepsilon cf} \leq 20$ K because of the cold-forming grade. The largest permissible product thicknesses for low reference temperatures T_{Ed} and further information can be obtained, where necessary, from the comment to [7] in the *Stahlbaukalender* (steel construction calendar) 2012 (Table 7, p. 375). For ratios $r_i/t > 15$, the cold forming for cold-formed circular hollow sections may be disregarded in the verification.

For cold-formed rectangular and square hollow sections, the value of the temperature shift brought about by the cold forming which has to be used is $\Delta T_{\varepsilon cf} = 35$ K for wall thicknesses $t \leq 16$ mm or $\Delta T_{\varepsilon cf} = 45$ K for wall thicknesses $16 \text{ mm} < t \leq 40$ mm. The further notes apply similarly to cold-formed circular hollow sections.

In justified cases, it is possible to deviate from the definition of the test temperatures and Chirpy impact energies laid down in DIN EN 1993-1-10, Table 2.1 while retaining the fracture toughnesses to be achieved. The fracture mechanics concept for selecting the steel grade as per DIN EN 1993-1-10 allows the equivalent conversion of the test temperatures when adapting the Charpy impact energies to be achieved.

5-V.3 Additional requirements for multi-axial stress states

Components which have multi-axial stress states as a result of the production conditions and/or the operational loads require special considerations when selecting the steel. This concerns nodal points between corner posts and diagonal braces in truss constructions, for example.

For components with multi-axial loads, the following special features shall be taken into account when ordering material:

	Materials in accordance with DIN EN 10025 -1,-3,-4 [8]	Materials in accordance with DIN EN 10210-1 [10]	Materials in accordance with DIN EN 10219-1 [11]	Materials in accordance with DIN EN 10225 [12]
Test piece orientation in the Charpy impact test	Additional verification of the Charpy impact properties on transverse test pieces (order option 30 in accordance with DIN EN 10025-3/-4)		Shall not be used for multi-axial stress states without additional measures	No additional requirements
Additional Charpy impact test in the centre of the metal sheet	Additional tests are required for metal sheet thicknesses $t > 40$ mm			

Table 5-V.2: Additional requirements placed on the Charpy impact test

The regulations on the choice of steel grade giving due regard to the through-thickness properties in accordance with [7] Section 3 shall be used, and the resulting additional requirements for the Z quality in accordance with DIN EN 10164 shall be taken into account in the order.

Appendix 5-VI Notes on the production in accordance with DIN EN 1090-2

The execution and monitoring of the execution is regulated in DIN EN 1090-2.

For offshore structures, the following execution classes at least shall be complied with:

- EXC 2 for structures which are predominantly stressed at rest
- EXC 3 for structures which are predominantly stressed when not at rest, such as foundation structures which are in sea water

The execution class selected determines the scope of the additional non-destructive test (NDT) in DIN EN 1090-2 (chapter 12.4.2.2 Scope of inspection, Table 24). In addition to the scope of the test for UT described there, more wide-ranging tests can become necessary depending on the test results. For the further procedure to adapt the scope of the inspection or testing, reference is made to chapter B2.4.2.1.2 Monitoring of the production phase (steel structures). The procedure described there is to be similarly applied to the UT tests.

Appendix 6 Corrosion protection concept to demonstrate durability during operating time for the 2nd release

1. Coating protection concept

- Division of the protection areas into zones (soil, immersion, water changes, spray, atmosphere) for internal and external surfaces,
- Outline including a representation of the protection areas and the respective security systems,
- Information concerning the composition of the coating layers (e.g. substance, number of layers, thickness of each layer, total coating thickness),
- Selection of systems per zone (system number in combination with the appropriate code of practice (Im2: ZTV-W, NORSOK M-501/ISO 20340, DIN EN ISO 12944; C5-M: ZTV-ING, NORSOK M-501/ISO 20340, DIN EN ISO 12944, for example); special approvals needed for other polymer systems not commonly used) – Note: Only includes systems for initial application - not repair coatings,
- Presentation of the edge protection system: Definition of the respective locations,
- Colour scheme, oil-repellent layer in the water change zone,
- Suitability verification - corrosion protection test for security systems (code of practice on which the approval test is based; extended verifications covering, for example, abrasive wear, CCP suitability),
- Comparison between operating time and the protection time that can be deduced from the approval tests,
- Preparation of the surfaces (according to ISO 8501, DIN EN 1090, etc.),
- Description of the application process, incl. notes on the repair concept,
- Application (e. g. *KOR-Schein* (corrosion protection qualification certificate) for foremen) and monitoring (for example a form according to DIN EN ISO 12944-8 and ZTV-W 218, in-house monitoring – external monitoring),
- Appraisal of a potential entry of pollutants (e. g. solvents) into the seawater,
- If necessary, presentation of electrochemical procedures.

2. Electrochemical Protection

- Division of the protection areas into zones (internal/external),
- Definition of protection areas and surfaces to be protected (coated/uncoated),
- Personal qualifications: Corrosion protection concept on the basis of DIN EN 15257 (minimum level 2),
- Calculation of the power requirements and the number of anodes needed,
- Galvanic anodes: Material consumption over 25 years, assurance of the uninterrupted availability of anode material on or within the structure,
- Information concerning metal accumulation (in g/m^3) in the water of the wind farm area due to galvanic anodes (worst case consideration),
- Impressed current (e. g. anode material, amperage, driving voltage),
- Number and type of anodes, durability (material removal).

3. Miscellaneous

- Material usage and combination of material usages (e. g. CrNi steel, structural steel) in the structure
- Informations on corrosion allowance (for unprotected surfaces, if applicable) and indication of the corrosion rates used
- Protection against mechanical damage (e. g. transport, collision on site)
- Appraisal of the possible microbially induced corrosion

Appendix 7 Terms and Definitions

Acknowledged Rules of Technology
An acknowledged rule of technology is a technical definition that is considered by a representative majority of experts as being the reproduction of the state of the art. The generally acknowledged rules of technology are not identical to the DIN standards (according to a decision issued by the German Federal Court of Justice, the DIN standards are private technical rules with recommendatory character) and other standards. The generally acknowledged rules of technology go far beyond the general technical specifications, to which the DIN standards also belong. As far as standards have been incorporated into the building regulations, these belong to the generally acknowledged rules of technology.

Appointed Inspector
The appointed inspector is an independent test, classification, or certification organisation with appropriately qualified personal or a certified inspector. The appointed inspector is to be presented to the BSH by the applicant or the approval holder and confirmed by the BSH.

The appointed inspectors are independent in the context of their incumbent duties (testing and certification) and are not bound to the instructions of the applicant/the approval holder.

In order to be recognised by the BSH, the requirements with reference to DIN EN ISO/IEC 17020 "Conformity assessment – Requirements for the operation of various types of bodies performing inspection" and DIN EN ISO / IEC 17065 "Conformity assessment – Requirements for bodies certifying products, processes and services", must be fulfilled.

As-Built Drawing
The as-built drawing includes the description of the actual physical inventory on-site (also following the completion of the decommissioning phase). It is fundamental for the entries in the nautical charts.

As-Built Report
The as-built report corresponds to the as-built drawing, i. e. the description of the actual situation on-site after the completion of the respective implementation phase, including all structural deviations from the final design which have to be accordingly indicated.

Basic Documents
Documents that contain the determined and measured on-site conditions. They form the design basis in combination with the design rules.

Bathymetry
Mapping of the topographical seabed relief.

Certified Inspector
Certified inspectors must be able to prove that they possess special knowledge in the test discipline through vocational training and experience and must have received accreditation by the governmental institutions in the respective discipline (for example according to the *Authorised Inspectors and Inspection Experts Ordinance, PPVO*).

Characteristic Values of the Soil Parameters
These are carefully selected mean values of a typical bandwidth of these values for the particular soil type under the circumstances to be considered, the magnitude of which is to be viewed as secured for the service life of the foundation. The geotechnical engineering model in which they are to be used, shall also be taken into account when defining them.

Collision Friendliness
Hull-retaining design and construction of the support structure.

Construction Jour Fixe
Meetings held with the BSH on a regular basis until the start of the operating phase.

Construction Log
The construction log is the daily documentation of the work carried out and the boundary conditions during the installation work, such as the external conditions (swell, wind, tide, ice drift) and any unusual occurrence.

Converter Station
The equipment of a converter station is similar to the equipment of an offshore substation but also includes technical equipment to transform alternating current into direct current.

The role of the converter station is to transport the power produced by the wind farms connected to it to the coast. Wind parks are combined to “clusters” and connected to the converter station through their respective offshore substations.

Cyclic Loads
Loads that result from effects with a high rate of regular or irregular, low-frequency magnitude changes, with or without changes of direction.
Note: Often the term *cycle* is used.

Damage-Tolerant Components
Components that, despite being damaged, are able to withstand the anticipated stress until the damage has either been detected and repaired during a scheduled inspection or as a result of a non-safety-relevant functional failure, are called *damage-tolerant components*.

Danger Zone
Danger zones are areas in the immediate vicinity of which dangerous situations may arise that require supplementary protective measures to reduce hazards or limit damage. Protective occupational safety and personal protection measures have priority. Furthermore, the protection of the environment and of property must also be observed. The typical danger zones of offshore structures are, for example, electrical switchboards and installations, areas with a higher fire load or risk of fire (tank systems, storage tanks, oil transformers), explosive areas, areas with load handling (working with a crane) or areas with an increased danger of falling.

Decommissioning
Decommissioning starts on the day that regular operation and/or the operating release granted by the BSH ends. This presupposes that the collateral clauses of the notice of approval as well as the stipulations of the approval process during the implementation and/or operating phase have been accordingly fulfilled.

Decommissioning Depth
Distance between the top edge of the decommissioned foundation element and the top ground surface (seabed).

Decommissioning Instruction Manual
The decommissioning instruction manual is a comprehensible and plausible representation of the scheduled work processes, including the technical boundary conditions. It begins with the preparation of the components for decommissioning and their removal on transport vessels to the base port (i.e. first port after decommissioning), including the decommissioning of the

submarine cable, the offshore wind turbine, the substation platform as well as all other structures. It serves, in particular, to describe and test the decommissioning processes for the individual components. The disposal verifications are not part of the decommissioning instruction manual.

Decommissioning Log
The decommissioning log is the daily documentation of the work carried out and the boundary conditions during the decommissioning work, such as the external conditions (swell, wind, tide, ice drift) as well as any unusual occurrence, such as an accident.

Decommissioning Statement
The decommissioning statement contains the description of the actual situation on-site after the completion of the respective decommissioning phase, including any deviations from the decommissioning instruction manual (final design) which must be accordingly indicated.

Design Basis
Set of relevant basic documents and design rules as well as applicable standards and directives and their hierarchy.

Design Rules
Rules, standards, directives, and approaches that define the engineering application of the on-site conditions as well as the assessment of the design. They form part of the design basis in combination with the basic documents.

Design Values of the Soil Parameters
Please refer to *Nominal Values*.

Dynamic Loads on the Subsoil
High-frequency periodic effects (vibrations) or intermittent transient effects (shocks) that create such a high stress modification rate in the ground that inertial loads cannot be neglected, and which principally establish small deformations of a constant volume with a quasi-elastic nature.

Emergency
Please refer to *Incident*

Emergency Operation
During emergency operation, the electrical supply of all the important devices with a safety function comes from a power source that is suitable for safety purposes. This power source is not intended to supply further devices for any reason or purpose other than safety. Emergency service is automatically initiated when all incoming supplies from the general electric power grid are interrupted and there is no other power system available to supply safety-significant devices.

Eurocode
General name of the DIN EN 199x standards series, including their respective national annexes and the additional rules included in the standards and normative referrals in their respective published versions (*White Copy*).

Evaluation Criteria
The evaluation criteria (for the periodic inspections) are to be fixed in the test and/or inspection plan at object and site-level.

Fatigue Limit State (FLS)
The FLS is an ultimate limit state. However, because of its importance, it is often mentioned separately.

In the fatigue limit state, in particular, sustainability issues relevant to service life that serve to calculate time-dependent component resistance and, hence, determine the mathematical service life, are taken into consideration (e. g. alternating loads).

This limit state has been reached when, with regard to the foundation, the sum of the loads on the subsoil have led to a reduction in either the stiffness or the firmness of the subsoil or parts of it, so that the stability and/or the serviceability of the foundation of the structure can no longer be guaranteed.

Foundation
The foundation is the connection of a structure to a good load-bearing subsurface so that the settling of the soil remains within acceptable limits.

Foundation Elements
The foundation elements are those design components that serve to position the support structure, in general the substructure, on or to anchor it into the subsoil. They distribute the necessary ensuing force safely, sustainably and with acceptable displacements and deformations, into the subsoil.

Geotechnical Expert
During the BSH approval procedure, the geotechnics expert is responsible for the ground investigation, examination and assessment which are part of the basic planning documentation for the objects included in the construction project on behalf of the applicant or approval holder. His/her tasks, in particular, result from the *BSH Standard Ground Investigations, Part A4 and C4.1*

Geotechnical Planning Expert
Special expert with expertise and experience in the field of geotechnics and head of the geotechnical design department. On behalf of the designer, he/she compiles the geotechnical contributions on the design of the foundation of the structures (must demonstrate expert knowledge and experience in the appropriate field of geotechnics) *(please refer to BSH Standard Ground Investigations, Part C 4.1)*

Grout
Grout (please refer to grouting) or concrete

Grouted Joint
A grouted joint is a connection between two steel pipes fitted into each other, whereby the gap in between these pipes is filled with mortar (for example, between the monopile and the transition piece that leads to the tower).

Grouting
Low-viscosity, high-strength grouting or concrete that may be used to bond structural components.

Implementation
Implementation refers to the physical deployment of the components into the maritime environment, from the base port to the location of the structure at sea.

Installation Manual
The installation manual provides a comprehensible and plausible representation of the scheduled work processes, including the technical boundary conditions, starting with the loading of the components onto the transport vessels at the base port (last port before the installation location) up to the completion of the implementation, such as the submarine cable feed-through into the so-called "J-tube" of the offshore wind turbine or substation platform. It serves, in particular, to present and test the implementation schedule of the structure.

Implementation Planning
In general, the implementation planning phase starts once the installation manual has been completed. It supplies documents according to which processes are carried out and the components to be implemented constructed and/or installed. The level of detail of the implementation plan complies with the available certifications and the certified processes, i. e. installation vessels, for example, operating within the framework of their operation regulations (e. g. class – certificate) do not have to be documented or inspected separately.

Implementation Planning
During the implementation planning phase, the preceding design plan (construction drawings and construction documents), resp. the approval plan must have been worked through in enough detail to allow the construction project to be completed. The implementation plans include all data necessary to erect or to rebuild the structure. Normally, for all trades that manufacture parts in advance at permanent manufacturing plants, the implementation planning phase is followed by a workshop planning or an assembly planning phase.

Incident
An incident or an emergency is an acute danger to human beings or material assets and/or an acute danger or disturbance, in particular of technical processes and infrastructures, that is relevant to preserving the functionality of the structure and that disturbs or interrupts the regular sequence of operations.

Independent Third Parties
Independent third parties in terms of this standard are: the appointed inspector him/herself or appropriately suitable inspectors as well as the certified inspector.

Initial Audit
The initial audit is intended to provide a meaningful, general view of the extent to which the management system has been incorporated into the implementation currently under consideration. Furthermore, the technical qualification of the operation is to be verified with regard to the upcoming task.

Inspection
Controlling measure conducted by in-house staff or by qualified agents in order to ascertain and to evaluate the actual state of the facility to be inspected (system, technical medium, object, etc.).

Isolated Operation
Operation mode of the power units when using the standby power system or the emergency power supply. In this case, the voltage and frequency are autonomously controlled.

J-Tube
Designation used in offshore engineering for a cable tube that features a bend at the bottom end in order to deflect the cable in a vertical direction along the foundation structure. Special funnels are provided to thread the cable into these tubes.

Jacket Structure
Support structure that is made out of a three-dimensional truss construction and which features three or more corner piles. The foundation piles are driven through sleeves that are arranged at the lower corners. Alternatively, suction bucket foundations can be arranged at the corner piles. The foundation piles can also be driven into place before the jacket structure is erected.

Maintenance
Measures to delay the degradation of the existing wear margin of the respective unit during operation. In general, maintenance is carried out regularly according to technical rules or according to the manufacturer's instructions – often by trained and qualified staff.

Manned Offshore Substation
An offshore substation is considered as being manned, if overnight stays are planned.
Monitoring Report

The appointed inspector describes and evaluates the results of the tests (for example periodic inspections or tests during the decommissioning phase) in a monitoring report in a comprehensible and plausible way.

Monopile
Large pipe that is driven or drilled into the soil. It acts as both the foundation element and substructure (resp. possibly only part of the substructure) of the offshore structure.

Nominal Values (Design Values) of the Soil Parameters
Values derived from the characteristic values of soil parameters, reduced (or, if necessary, increased) by the partial safety factor. The use of nominal values is necessary for calculations where the partial safety factor is not or not exclusively applied to ground stress (calculated using the characteristic values of the soil parameters). These are to be fixed in consideration of the geotechnical engineering model in which they are to be used.

Non-Damage-Tolerant Components
Components that are not capable of withstanding the expected load resulting from damage are called *non-damage-tolerant components*.

Normal Operation
During normal operation, operation conditions remain within the normal operating parameters. Normal operation also encompasses the operation conditions during a shutdown, maintenance, preservation and repair work.

The electrical connection to the onshore grid is serviceable, energy can be transmitted in both directions and the power requirements of the offshore substation can be covered by the onshore grid. The substation is able to handle failures of single components according to the agreement.

Offshore Station
An offshore station or an offshore platform is an offshore structure (offshore installation). It is an artificial floor space in the sea which includes all the necessary infrastructural components and safety equipment that guarantees a safe workplace and a safe stay and also protects the environment at all times and under all weather conditions. Different design options are available, depending on the use and the size of the station and the geological conditions at the future site.

Offshore Structure
Offshore structures in terms of this standard are those offshore installations that are permanently installed or only installed short-term for a specific purpose and floating structural or technical facilities, including artificial islands. Each of the above include the auxiliary equipment necessary for its implementation and operation that serve:

- the generation of energy from water, current and wind,
- the transmission of energy from water, current and wind,
- other economic purposes or
- oceanographic examinations.

Non-offshore structures in terms of this standard include ships as well as floatable platforms and ships transformed into platforms, even though these may be attached for recommissioning purposes, and are not subject to sentence 1 above, navigation signs, facilities that are approved according to mining regulations, facilities that require monitoring in terms of statutory product safety regulations as well as passive fishing gear used by the fishing industry (for a more detailed definition, please refer to *Marine Facilities Ordinance, Art. 1*).

Offshore Substation
An offshore substation is part of an offshore wind farm and serves to connect up the different voltage levels between the cabling within the wind farm and the export cables that either run directly to the coast (alternating current connection) or to the converter station (direct current connection).

Apart from power transformers, an offshore substation always consists of switchgears, further measuring and control technology and auxiliary systems aimed at upholding operations.

Offshore Vehicle Coordinator (OVC)
The offshore vehicle coordinator coordinates all maritime and flying traffic between the base port and the implementation zone and is the first person to be contacted by the rescue teams in the event of an emergency. He/she has to be available 24/7 and must be reachable by all the operating units. He/she must have a general overview of all the persons situated within the implementation zone and their valid training certificates. He/she has to be notified of all work in advance.

Offshore Wind Turbine
Wind turbine on the open seas in accordance with IEC 61400-3

Operating Release
Upon the granting of operating release, the project enters the actual operating phase – from an administrative perspective. The operating release is granted only once.

Operating Permit
The operating permit for an offshore wind farm or an offshore structure is granted or withdrawn by the BSH in conjunction with the operating release and is required for its operation. After a reported interruption during the operating phase, an “operating permit” to resume operation is granted.

Operational Structure
The structure that is mounted on top of the support structure and which fulfils the main function of the construction (rotor/nacelle assembly in the case of an offshore wind turbine, resp. topside in the case of an offshore substation).

Operations Manual
The operations manual describes all the significant processes and their dependencies that ensure the safe, long-term operation of the facility. It includes the description of the workflow (operational concept) and the respective communication channels as well as the ongoing monitoring (operations-related monitoring) of the offshore wind farm and the grid connection.
Periodic Inspections

Periodic inspections in terms of this standard are regular tests of the components of an offshore structure by the appointed inspector/certified expert. These serve to ascertain and to evaluate the actual state of the test object. The periodic inspections take place according to a test and inspection plan which is compiled by the operator and coordinated with the appointed inspector.

Planning Results
Calculation results, proof of strength, drawings, specifications and implementation notes, based on the design rules and basic documents.

Preliminary Design
First draft of the possible planning design variants of the support structure and the foundation elements in order to evaluate whether the project is basically technically feasible. The preliminary design is based on the design basis. As a rule, the type of offshore wind turbine has still to be fixed at the time of compiling the preliminary design. For this reason, the key technical RNA data may be estimated for the assessment within the scope of the preliminary design using possible variants.

Preservation
Preservation encompasses all measures that help to maintain functionality. The DIN 21051 standard divides preservation into four basic measures: Maintenance, inspection, repair, improvement.

Primary Structure
Support structure located within the main power flow.

Project Certificate
The project certificate is issued after the completion of the implementation phase. This encompasses all the phases from development to implementation, including all the individual stages thereof (e.g. manufacturing, loading, transportation, etc.). An appointed inspector performs independent tests and inspections and monitors and documents the results throughout all stages. At the end of each stage, a certificate of conformity that summarises the test and inspection reports is issued by the appointed inspector. Once all the required certificates of conformity in conjunction with the certificate of conformity pertaining to the monitoring of the commissioning phase have been presented, a project certificate can be issued.

Protection Area
Protection areas are spaces where persons are protected, for a limited duration, against damage resulting from specific hazards. In the case of offshore structures, this mainly involves danger as a result of a fire, caused by smoke, fire, heat and the consequences of the mechanical or chemical destruction of the surrounding components. Furthermore, protection areas to provide shelter and protection against harsh weather conditions may also be created.

p-y Method
Modulus of subgrade reaction method with non-linear, soil type and depth-dependent spring characteristics for the design of foundation elements.

Repair
This encompasses all measures to be taken in order to restore functionality after an incident.
Restricted Area

Restricted areas are areas that contain technical facilities that are important to both safety and operations that primarily require protection from unauthorised access and basic hazards in order to ensure these facilities function as expected at all times. Secondarily, preventing access to restricted areas may also protect untrained personal from specific hazards, such as areas where electrical equipment is operated and battery installations.

Rotor/Nacelle Assembly (RNA)
Part of an offshore wind turbine that is maintained by a support structure, see Figure 1-1. The rotor/nacelle assembly consists of a nacelle and rotor blades. The RNA includes the screw connection to the tower flange that is the interface to the tower which is part of the support structure. The fixtures/components in the support structure that are necessary for the operation of the RNA are part of the RNA (for example converter, transformer, switchgear cabinets).

Safety System
The safety system is intended to ensure that the facility remains in a safe condition in the event of a disturbance.

Scatter Diagram
A scatter diagram is the graphical representation of an observed pair of values of two statistical attributes. These pairs of values are plotted into a Cartesian coordinate system which results in a bivariate point distribution (scatter).

Scour
Deepening of the seabed in the area of the foundation structure due to current-induced mineral erosion.

Secondary Structure
Built-on accessories, machine-mounted accessories and fixtures that are attached to the primary structure and located outside the main power flow.

Serviceability Limit State (SLS)
State beyond which the defined conditions regarding the serviceability of a support structure or a component are no longer fulfilled.

With regard to the foundation, this limit state is reached when an increase of the effects (service loads) would lead to intolerably large total displacements or permanent displacements of the subsoil, the foundation elements or their components.

Shear Keys
Shear keys are welded reinforcements around the outer surface of a pile and at the connection piece in the grouted area. The shear keys are intended to increase the sustainability of the joint between the mortar and the steel.

Soil (Loose Rock)
Superordinate material designation for the different layers of subsoil.

Standby Power Supply
When standby power is being used, standby power units replace the general electric power grid (onshore grid connection) in order to ensure the power requirements of the offshore substation are met. Furthermore, if the power units are suitably designed, it may also be possible to supply standby power to all the wind turbines. The power units regulate the grid autonomously in the "isolated operation" mode. Standby power operation is a normal mode of operation so that it is not necessary to supply safety-significant devices with emergency power.

State of Current Scientific and Technical Progress
The state of current scientific and technical progress is the stage of development of the most advanced processes, facilities, and operating methods that, according to the opinion of leading science and technology experts, and on the basis of new, scientifically supportable knowledge with regard to the statutory objective, are considered as being necessary.

State of The Art
The state of the art is the stage of development of advanced processes, facilities, or operating methods whereby the practical adequacy of a measure to ensure installation safety generally appears to have been confirmed.

Static Loads or Quasi-Static Loads on the Subsoil
These result from impacts which principally have magnitudes with a monotonic structure and only change insignificantly or which only occur rarely (as maximum magnitude).

Status Report
Report concerning the condition of offshore structures, including the monitoring report from the periodic inspections of the offshore structures.

Subsoil
System composed of one or multiple layers of soil or rock, including all substances (for example ground water and contaminations) in and on which the structures are or are to be founded or embedded and which will be influenced by the construction project (DIN 4020).

Subsoil Model
The subsoil model is the simplified geometrical model of the subsoil conditions at the location of a structural facility, defined as a geometrical formation of homogeneous areas (layers) for which uniform characteristic values of the geotechnical parameters are indicated in order to design the foundation elements of the structural facility.

Substructure
Part of the support structure above the foundation elements and underneath the tower (offshore wind turbine) or the top deck (offshore substation), please refer to B1.1.

Suction Bucket Foundation
The suction bucket foundation was developed on the basis of the suction caisson foundation frequently used in offshore technology. This is a combination of pile foundation and heavy weight foundation.

Suffosion
Suffosion (erosion by solution, surface solution) is the rearrangement of fine soil particles by water flow. Fine grains of irregular cohesionless soil are transported by the flow force of the water through the pore space.

Support Structure
The support structure supports the installation.

The support structure of an offshore structure as referred to in this standard encompasses all the structural components and facilities that are located between the seabed and the operational structure (please refer to Fig. 1-1 and Fig. 1-2), except the foundation elements.

A component of a structure may have its own support structure (e.g. topside).
Test and Inspection Plan of the Periodic Inspections

List of the schedule and content of the planned tests and possible inspections pertaining to periodic inspections. The test and inspection plan for periodic inspections is compiled by the operator and coordinated with the appointed inspector.

Testing
Controlling measure conducted by independent, qualified and recognised third parties in order to determine and evaluate the actual state of the object to be inspected (system, technical medium, object, etc.).

Topside (Operational Structure)
Upper structure of an offshore substation that is located on top of a substructure and contains the entire technology or equipment necessary for operation (operational structure).
Tripile Structure

Part of a support structure where the (three) foundation piles are led above the water level and then joined in a top structure.

Tripod Structure
Part of a support structure where a steel pipe is placed on top of a tripod made of steel pipes. The struts of the tripod may consist of one or several piles. The foundation is achieved by connecting piles to a tripod.

Truss Construction
Please refer to *Jacket Structure*

Ultimate Limit State (ULS)
Any state that is associated to the collapse or any other form of failure of the support structure. This generally corresponds to the greatest load-bearing capacity of the support structure or supporting components.

With regard to the foundation, this limit state is reached when the resistance increases to such an extent that an intolerably high strain is placed on the subsoil, the foundation elements or their components.

Unmanned Offshore Substation
An offshore substation is considered as being unmanned, if a scheduled stay only takes place during working hours; there are no planned overnight stays.

White Copy
A White Copy is the published, binding, and final version of a DIN standard.

Wind Farm Layout (of an Offshore Wind Farm)
A wind farm layout is the arrangement of the structures at an offshore wind farm and includes the position of the offshore wind turbines, the substation(s) and, if applicable, the measurement masts.

Workshop Planning
Workshop planning or assembly planning normally takes place once the final design has been finalised. It delivers documents which can be used for the construction/installation of each and every single detail.