EI 3617

Managing the risk of moving, installed WTG blades striking a vessel

First edition

G+ Global Offshore Wind Health & Safety Organisation

In partnership with energy institute

G+ GOOD PRACTICE GUIDELINES

MANAGING THE RISK OF MOVING INSTALLED WTG BLADES STRIKING A VESSEL

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The contents of these guidelines are intended for information and general guidance only, do not constitute advice, are not exhaustive, and do not indicate any specific course of action. Detailed professional advice should be obtained before taking, or refraining from, action in relation to any of the contributors of this guide, or the relevance or applicability of the information herein.

PRESENTATION

Information in standard black text introduces the background to or rationale for the requirements, providing understanding and discussion of the issues involved.

The guidelines themselves are concise statements of G+ recommendations. They are numbered and boxed, shown in bold text.

TERMINOLOGY

The following terms have special meanings in this good practice guideline (GPG):

Design (as in 'safety by design') is used to include all the life cycle stages that need to occur before a vessel approaches a wind turbine generator (WTG). The activities in these stages include, for example, the specification or selection of system elements and decisions about logistics and operations, as well as conceptual or detailed design of the WTG itself.

Ensure. Where a guideline states that offshore wind companies (OWCs) should 'ensure' something, it means that they should arrange for it to be done, and check and assure themselves that it is being done. It does not mean that they should necessarily do it themselves.

May indicates a guideline whose suitability depends on circumstances, as in '…it may be helpful to…'. It is also used to describe different possible cases that need to be considered, as in, for example: '…there may be multiple sites from which a WTG can be controlled'.

Must/shall. G+ does not have legal authority to mandate requirements, so terms such as 'must' and 'shall' are not used, except when citing legal requirements.

Offshore wind company (OWC). This GPG is intended for all parties involved in the management of vessel/WTG operations. Primarily, these will be client organisations (wind farm owners, operators and developers), as well as their high-level (Tier 1 and 2) contractors such as vessel operators and original equipment manufacturers (OEMs). Such organisations are collectively referred to as OWCs in the document. OWC is a deliberately broad term, since the parties involved will vary from project to project, and how responsibilities are shared between them will depend on contractual arrangements.

Personnel. This term is used to include anyone present on or around a site, whether they are employees of the OWC or of other organisations.

Should. Consistent with other G+ good practice guidelines, this document uses 'should' as the default term for good practices that G+ expects. This allows for flexibility in the means of achieving the safety aims but does not mean that the practice is merely optional. Rather, G+ expects wind companies to either:

- follow the guidelines (and go beyond them wherever reasonably practicable);
- do something else at least equally safe, or
- risk assess, justify and document the acceptance of any exemption.

Vessel approach. This term is used as shorthand for the full cycle of a vessel attending a WTG, including approach itself, station keeping and operations at the WTG, and departure.

CONTENTS

Contents continued

Page

LIST OF TABLES

1 INTRODUCTION

This good practice guideline (GPG) aims to advance, share and encourage good practice for the management of safety risks associated with moving installed wind turbine generator (WTG) blades striking a vessel.

A collated list of all the good practice guidelines themselves (i.e. the main 'should' statements) is in Annex A.

1.1 BACKGROUND

The G+ Global Offshore Wind Health and Safety Organisation (G+) is the health and safety (H&S) organisation for the offshore wind sector, providing leadership in H&S, ensuring transparency about the industry's H&S performance and helping stakeholders ensure that risks are controlled through cooperation and shared learning. The Energy Institute (EI) provides the secretariat function for G+ and supports its work.

The G+ safety data (https://www.gplusoffshorewind.com/work-programme/workstreams/statistics) include incidents of moving blades striking vessels. Details of some such incidents can be found on the EI Toolbox https://toolbox.energyinst.org/home, a web-based app that allows the energy industry to share learning and experience from incidents.

For example:

- *Nacelle yaws automatically during vessel approach* | Toolbox (energyinst.org)
- *Poor pre-task planning results in turbine blade contacting adjacent vessel* | Toolbox (energyinst.org)
- *Turbine blade strikes gangway, tipping it into the sea* | Toolbox (energyinst.org)
- *Miscommunication results in incorrect turbine activation, endangering vessel* | Toolbox (energyinst.org)

There are also some International Marine Contractors Association (IMCA) Safety flashes:

- *Yawing of wind turbine nacelle placed ship in line of fire*
- *Near miss: Vessel approach to wind turbine tower*

While such incidents have not to date resulted in physical harm to individuals, G+ members, associates and other organisations have shared increasing concerns about the risk to personnel. To help address these issues, a G+ working group (WG) of subject matter experts from G+ member companies was established to support the development of this GPG.

1.2 OBJECTIVES

This GPG aims to advance, share and encourage good practice for the management of safety risks associated with installed WTG blades, which are in motion, striking a vessel. It sets out the collective expectations of G+ members.

1.3 AUDIENCES AND USES OF THE GPG

This GPG is intended for all parties involved in the management of vessel/WTG operations or WTG design. Primarily, these will be client organisations (wind farm owners, operators and developers[1]), as well as their high-level (Tier 1 and 2) contractors such as vessel operators and original equipment manufacturers (OEMs).

All such organisations are collectively referred to as offshore wind companies (OWCs) in this document. OWC is a deliberately broad term, since the parties involved will vary from project to project, and how responsibilities are shared between them will depend on contractual arrangements. For example, it will usually be the OEM that develops the WTG design, but clients select the WTG model(s) for their wind farms and may have some influence on the design.

The GPG is a resource for OWCs to adopt and implement within their own safety management systems (SMSs). It could be used to, for example:

- provide a baseline from which to establish common ground between project parties, helping to ensure consistent expectations and compatible approaches;
- incorporate into company standards, procedures and practices;
- incorporate into contract specifications, and
- provide prompts for use in gap analyses, audits and reviews.

The GPG may also be of use to other interested parties, such as H&S professionals in the wind industry, other industries that interface with offshore wind and H&S regulators.

1.4 SCOPE OF THE GPG

1.4.1 Focus and emphasis

The focus and emphasis of this GPG is on moving installed WTG blades striking a vessel. The situations considered are those in which hub rotation or nacelle yaw bring a blade into contact with a vessel, posing safety risks to personnel on the vessel, the WTG or the transfer system.

The guidelines in this GPG are equally applicable when the vessel is stationary and when the vessel is moving (under its own power or due to wind, wave, swell, tide or current). However, where the vessel (or a floating WTG platform) is moving as well as the blades, this may bring the vessel closer to the blades and hence increase the risk of blade strike (see 2.6 for further details).

Although some of the risk control measures may be the same or similar, this GPG does not cover vessels colliding with static blades or with other parts of a WTG – the cause of such incidents can vary significantly and are addressed in wider G+ and other publications on vessel management and marine coordination. A more complete list of scope exclusions is given in 1.4.3.

1 Sometimes referred to as offshore renewable energy developers (OREDs).

1.4.2 Inclusions

The GPG is applicable to:

- any location globally – the GPG is intended to be applicable internationally, but the source materials and experience have necessarily come principally from the regions where G+ members are most active: Europe, the USA and parts of Asia;
- fixed and floating WTGs;
- all physical elements of vessels, including the vessel bridge and superstructure, and any transfer system towers/gangways, onboard cranes, helicopter decks, radio masts, etc., that may protrude above or outside the envelope of the main vessel structure;
- life cycle stages once the blades are installed, i.e. commissioning, operation, planned or unplanned maintenance, repowering and planned or unplanned decommissioning/dismantling;
- planning and design for the above life cycle stages, and
- abnormal conditions and emergencies.

1.4.3 Exclusions

To address, in adequate depth, the specific causes of blades in motion striking a vessel, the following are **not** covered in this GPG:

- as noted in 1.4.1, vessels colliding with static blades or other parts of a WTG;
- blade/vessel impacts during the construction/installation life cycle stages, such as a blade being dropped on to or swung into a vessel while being lifted into position;
- blade throw, ice throw and other objects (hatches, maintenance tools and equipment debris, etc.) falling from a WTG on to a vessel;
- detailed technical aspects, such as the design of WTG control systems or vessel dynamic positioning (DP) systems;
- hazards associated with vessels or transfer systems themselves, e.g. a vessel loss of control, collapse of a walk-to-work (W2W) gangway;
- remotely operated vehicles/vessels (ROVs), as managing the risks associated with ROVs would require many other aspects to be considered;
- details of legislation or guidance in individual regions or states, and
- generic H&S management, e.g. common principles and practices of risk assessment, the hierarchy of control or human factors. We have aimed to avoid giving generic advice on safety management, but to highlight aspects specific to the risk of moving installed WTG blades striking a vessel. It is assumed that audiences already have an appropriate SMS in place.

1.4.4 Technical approach

The development of the GPG involved:

- regular meetings with, and input from, the WG and the EI secretariat;
- a literature review covering regulations, regulatory guidance, standards and industry guidance, as well as examples of relevant OWC documents, such as vessel approach procedures and risk assessments, provided by the WG;
- a search for reports of incidents in the G+ incident database and EI Toolbox, and stakeholder consultation.

1.4.5 Structure of document

After the introductory section 1, the guidelines and additional guidance are presented in sections 2 and 3.

Section 2 covers safety by design, i.e. ensuring safety in the specification and design or selection of system elements.

Section 3 covers on-site (and ‘on-the-day’) safety, i.e. implementing the safety arrangements as designed, and refining, updating or expanding on them to allow for factors that could not be fully considered in the safety by design process.

Table 1 shows how sections 2 and 3 relate to the life cycle stages of a wind farm, and what the principal safety activities are in each stage.

Table 1: GPG structure, in relation to life cycle stages and safety activities

<table>
<tr><th>Guideline section</th><th colspan="2">Life cycle stage</th><th>Principal safety activities</th></tr>
<tr><td rowspan="2">2</td><td rowspan="2">Desk-based</td><td>Concept</td><td rowspan="2">Safety by design: ensuring safety in the specification and design or selection of system elements (people, procedures and equipment)</td></tr>
<tr><td>Design</td></tr>
<tr><td rowspan="2">n/a</td><td rowspan="7">On-site</td><td>Site surveys</td><td>Out of scope (blades not yet installed)</td></tr>
<tr><td>Construction/installation</td><td>Out of scope (blades not yet installed)</td></tr>
<tr><td rowspan="5">3</td><td>Commissioning</td><td rowspan="5">Implement the ‘safety by design’ arrangements developed in line with the guidelines in section 2
Refine, update or expand on the safety arrangements to allow for factors not fully considered in the safety by design process</td></tr>
<tr><td>Operations and maintenance (O&M)</td></tr>
<tr><td>Modification</td></tr>
<tr><td>Decommissioning</td></tr>
<tr><td>Abnormal and emergency situations</td></tr>
</table>

Section 4 summarises the key takeaway messages of the GPG.

The annexes provide additional details, supporting information and some example materials. It is essential to note that example materials are purely illustrative: they do not set benchmarks for what is appropriate and are not necessarily suitable, ready-made solutions for all situations. OWCs should not simply copy them into their own documentation, but should consider their specific projects, operations and contexts thoroughly.

2 GUIDELINES – SAFETY BY DESIGN

The guidelines in this section cover safety by design, i.e. eliminating or minimising hazards and risks from the earliest stages of the life cycle, before any vessels actually approach WTGs. These activities include, for example, the specification or selection of system elements, and decisions about logistics or operations, as well as the conceptual or detailed design of the WTG. For brevity, this GPG uses the term 'design' to include all such activities.

Guidance on safety by design in general is available in G+ GPG *Safe by Design – Good practice guidance for the offshore wind industry*.

A guideline on the need for a whole-system view is stated in 2.1.

More detailed guidelines on key aspects of design are then presented as follows:

– WTG/vessel access (2.2);
– control, communications and surveillance (CCS) (2.3);
– procedures: steps to be carried out/confirmed (2.4);
– risk assessments (2.5), and
– blade clash analysis (2.6).

In practice, these aspects are interdependent, and the activities related to them should be carried out iteratively. For example, the design of the WTG access features should be informed by the risk assessments and blade clash analysis.

2.1 WHOLE-SYSTEM VIEW

Guideline 1: OWCs should take a whole-system view when developing the wind farm design

The WTG-vessel system can be considered in terms of, for example:

– physical elements: infrastructure, assets and equipment such as WTGs, vessels, transfer systems, control, communication and surveillance systems;
– people: their roles and responsibilities and the lines of communication between them;
– WTG procedures: e.g. for setting and holding nacelle yaw and blade rotation in position, and for re-energising;
– vessel procedures: approach, activities at the WTG such as personnel transfer or delivery of equipment, departure;
– the life cycle stages (see Table 1), and
– the interactions between all of the above.

2.2 WTG/VESSEL ACCESS

Guideline 2: OWCs should eliminate or minimise risk through appropriate design of WTG access arrangements and of vessel logistics and approach plans

2.2.1 WTG design

Design aspects for particular attention include the provision (number, location and design) of features that affect or enable intentional access or other interactions between vessels and WTGs, such as:

- access gates;
- attachment points for W2W gangways or bring-to-work (B2W) systems;
- davit cranes;
- transfer ladders, and
- reference points used by DP vessels.

These will usually be determined primarily by the need to allow for the safe approach and operation of the range of vessels, for various tasks, in as many combinations as possible of WTG position and status and wave, swell, tide or current directions.

The design should also consider how the geometry of the WTG affects the clearance between blades and vessels.

2.2.2 Setting and holding the WTG in position for vessel approach

Before a vessel approaches a WTG, the nacelle heading will normally be set to a position that minimises the likelihood of blade clash. Typically, the nacelle will be yawed to position the rotor on the opposite side of the tower to the vessel landing or connection point.

The rotational position of the hub and blades may also be set, although some OWCs allow vessel access with the blades idling in certain situations. This is to minimise wear on the bearings, especially with larger, heavier WTGs. If it is intended to allow vessel approach with idling blades, the decision should always be subject to risk assessment, and additional controls being put in place as appropriate, such as an extra person on the bridge keeping a look out for any movement of the nacelle or blades. Note that there may be different designs of WTGs in a wind farm, with some for which idling is allowed and some not.

The required positions may vary, depending on factors such as the vessel type and the operations to be carried out (e.g. where a jack-up vessel is to be positioned near to a WTG, without the need for a transfer), metocean conditions on the day and what other safety controls are in place.

Once the WTG is in the position required, it needs to be held in place. There are various methods of doing this: physical, electrical or electronic, remotely or locally. Codes, either collective or personal, may be set which have to be re-entered to release the hold once the work is complete and it is safe to do so.

The industry uses various terms for this holding in position: 'lock', 'immobilise', 'stop', 'isolate', etc. These can have different meanings in relation to how and at what level of control it is achieved. The terminology is not always used consistently, however. Care is needed to ensure that those involved understand any safety implications – see 2.4.

Note: Although outside the scope of this GPG, as it is not a blade/vessel strike issue, it is important to be aware that there are serious risks to personnel working on a WTG if it is not under effective protection (e.g. local control with lock-out/tag-out) against inadvertent energisation, nacelle yaw, hub rotation, etc. The design should take such risks into account as well as blade/vessel strike.

2.2.3 WTG marking, lighting and signage

Aids to navigation, such as marking, lighting or signage of key features, may help to reduce risk. For example, lighting the downward-pointing blade could help vessel masters to detect any unintended movement, as well as to control the approach more accurately. OWCs may also wish to consider status/warning lights or signs to indicate whether a WTG is held in the required position.

Any marking, lighting or signage will need to be designed to maximise the benefits and avoid issues such as potential confusion with other maritime (or aviation) visual aids. The design should comply with international, regional or national requirements and standards (e.g. International Organization for Marine Aids to Navigation (IALA), G1162 *The marking of offshore man-made structures*).

2.2.4 Vessel logistics and approach

The design of the WTG should be iterative with that of the vessel logistics and approach plans. As the design is agreed ahead of these plans, the design should be suitable for different foundation and vessel logistics. For example, it should include consideration of how to deploy technicians to a 'dead' WTG if the nacelle heading prevents access to one or more W2W attachments or access gates. Having the ability to access a boat landing using a crew transfer vessel (CTV) or a daughter craft, rather than by W2W, could be one solution in this case, for example.

The logistics and O&M strategy should aim to minimise the number of scheduled connections. This will help to reduce the other risks (and environmental impacts) associated with vessel approaches, as well as the specific risk of moving installed blades striking a vessel.

Imposing a vessel speed limit can help to reduce the probability of a vessel infringing a safety (exclusion) zone and of being unable to take avoiding action in time if a blade does begin to move during the approach.

Early engagement with vessel operators is advisable. For example, vessel operators could, where possible, be given information about asset design from the procurement stage. Also, it may be beneficial to work with vessel operators to develop checklists for vessels entering safety zones. The checklist items could include, for example, requirements to confirm at various stages of approach (via automated systems, visually or by confirmation with wind farm personnel, etc.) that the WTG has been correctly identified and is in a safe state.

2.3 CONTROL, COMMUNICATIONS AND SURVEILLANCE (CCS)

Guideline 3: OWCs should ensure that the CCS architecture and technologies are designed/selected to maximise functionality, usability, performance, reliability and integrity

Control, communications and surveillance (CCS) systems have many functions, and in most cases, the safety aims in relation to the risks of moving installed blades striking a vessel will be the same as for other functions, for example to maximise coverage, reliability and transmission quality. However, situations may arise in which the aims related to the specific blade/vessel strike issue need to be balanced against those for other risks, or where the advantages of having a universal, consistent system outweigh any benefit that might arise from treating vessel/WTG CCS as a special case with different arrangements.

Aspects of the risk of moving installed blades striking a vessel that are likely to require particular attention in developing the CCS systems are that there may be:

- Multiple sites from which WTGs can be controlled: a remote-control room, a vessel, locally on the WTG.
- Multiple parties with the ability/responsibility to control WTGs, such as:
  - the wind farm operator or maintenance provider, remotely;
  - a local supervisor on board the vessel, putting the WTG into position ahead of vessel approach, and/or
  - personnel on board the WTG, controlling it locally.
- A large number of WTGs being controlled from each control centre: the user interface and display for control/supervisory control and data acquisition (SCADA) systems will need to provide a clear overview of WTG status, indicating which WTGs are under autonomous control, energised, idling, in position for vessel approach, under local control, etc.
- Different control systems on different WTGs (there may be more than one WTG design in a wind farm).
- Multiple modes of communication (including VHF radio channels, Tetra radio, phone, email, MS Teams chat, WhatsApp, etc.), with not all parties being able to use all modes.
- Risk of a cybersecurity breach, enabling remote access by an external party.

Guideline 4: OWCs should ensure that CCS systems are in place as early as possible in the life cycle

For a vessel to approach a WTG safely, it is important to know the WTG status, nacelle heading and rotor position, and to be able to control them. To enable this, the WTG must have power (battery or generator if the grid is not yet available, or as backup if there is a grid outage), communications (fibre, 4G or satellite) that are available even off-grid, and a SCADA system.

Closed circuit television (CCTV) systems on neighbouring assets can be useful in verifying the status of a WTG that has had a loss of communications.

2.4 PROCEDURES

Guideline 5: OWCs should develop procedures defining the steps to be carried out by each party, and the associated communications

2.4.1 Procedure contents

Procedure designers should consider and clearly define, for all steps:

(a) why the procedure is necessary;

(b) who is responsible for each action;

(c) where a WTG can be controlled from more than one point, who has primacy of control;

(d) what communications are required;

(e) the lines of communication (from who and to whom);

(f) requirements for closed loop communication (transmit-readback-confirm);

(g) requirements for monitoring or confirmation of actions taken (e.g. visually, by radar or automatic identification system (AIS), or from control centre indications);

(h) mode(s) of communication to be used (radio, phone, etc., including specific frequencies);

(i) the language to be used (noting that many sites will have an international workforce);

(j) standard phraseology or protocols to be observed, such as use of the phonetic alphabet – see International Maritime Organization (IMO), standard marine communication phrases (SMCP), and

(k) what records should be made, and who should receive them.

Not all of the above details need to be included in procedures as used on the day by operational personnel. Simple checklists, instructions, etc., tailored to the needs of each role, may be sufficient. Some aspects (such as language and phraseology) may be covered in higher-level procedures or training and should be agreed in advance, noting that for some sites, multiple languages may be required. However, it is important that everyone involved understands the 'why' of procedures, as in (a), and that all the above points are considered when designing procedures.

2.4.2 What should happen and what can go wrong

As well as defining what should happen, in line with safety by design principles, procedures should cover what could go wrong (see 2.5), defining contingencies for failures, errors, abnormal situations and emergency responses.

2.4.3 Parties involved

The parties who use procedures, or who need to be considered in designing them, typically include, but may not be limited to, those in Table 2.

Table 2: Examples of parties who use procedures, or who need to be considered in designing them

Parties	Description/examples
Wind farm personnel	Personnel transferring, or awaiting transfer, to or from a WTG, such as maintenance technicians Contractors involved in any stage of the life cycle (see Table 1)
Vessel crews	Especially the vessel master and officers of the watch, operators of W2W and B2W systems, and any crew acting as local WTG controllers while on board the vessel
Control centres	OWC control/SCADA/surveillance centres, marine coordination centres, wind farm emergency coordination centres
Parties involved in simultaneous operations (SIMOPs)	Those involved in other activities within or near the wind farm, e.g. ongoing work in the WTG being approached, helicopter hoisting, work on nearby WTGs or wind farms
External parties	Non-wind farm vessels entering or transiting the wind farm, with or without authorisation
Emergency services	Coastguard, search and rescue, etc

2.4.4 Illustrative example procedure

Annex B gives illustrative examples of the steps typically involved in a vessel approach procedure. It only shows 'on-the-day' steps and excludes those for safety management across the life cycle, such as for the design risk assessments or safe by design activities that should take place earlier.

Note: the steps shown in Annex B are purely illustrative and are not necessarily suitable for all situations. There may be variations in the nature and order of the steps, depending on factors such as the type of work to be carried out, whether personnel are already on the WTG, the WTG status and configuration at the start of the activity, and the available control and communication modes. OWCs should not, therefore, simply copy the content of Annex B into their own procedures, but should consider each specific project, operation and context thoroughly.

Guideline 6: OWCs should ensure that procedures are user focused

Key ways to reduce risk are by ensuring that procedures:

- involve user representatives in their development – personnel with experience of the activity and/or those who will be expected to follow the procedure;
- are clear and easy to follow, in the pre-agreed language(s) to reduce the likelihood of error or non-compliance;
- use terminology that will be clear to users. For example, as noted in 2.2, various different terms (lock, immobilise, stop, isolate, etc.) are in use for holding a WTG in position during vessel access. These terms can have different meanings in relation to how and at what level of control this is achieved, but they are not always used consistently. It is important to ensure that those involved understand the safety (and other) implications of the method of holding in place, e.g. whether it may be vulnerable to unintended removal, and
- are fail-safe, so far as reasonably practicable.

2.5 RISK ASSESSMENT

Risk assessment and design should proceed together, with risk assessments informing safety-led design.

Guideline 7: OWCs should ensure that the system design is underpinned and informed by suitable and sufficient risk assessment

The situations in which a moving installed blade could potentially strike a vessel are varied and complex. As a result, a systematic and thorough approach to risk assessment, and to the identification and consideration of risk control measures, will usually be required. It is unlikely to be suitable and sufficient simply to, for example, assess the risk by making judgements about the overall likelihood and consequences of such events in a traditional risk matrix.

The factors that lead to variations and complexities in the situations where this risk could arise include:

- The many different failures, errors or external conditions that may cause or contribute to the risk. For example, gaps or weaknesses in procedures, personnel not following procedures as intended, and equipment failures such as loss of communication. Annex C lists some potential causes and contributory factors, identified from incident reports and example risk assessments, procedures, etc. provided by WG members. It is essential to note, however, that this is intended to provide a starting point and prompts, rather than a comprehensive checklist.
- The various possible WTG states (operational, shut down/locked, fault condition, etc.) and configurations (nacelle yaw, hub rotation, etc.) and the available controls.
- Vessel-related factors, such as vessel size or availability of communications.
- The different actors involved – vessel crews, control centres, personnel on the WTG etc – and variations in their roles and communication/control abilities from one project to another.

Tools available for systematic and thorough analysis include structured hazard identification (HAZID) and analysis, using information from HAZID workshops, failure modes and effects analyses (FMEAs) and bowtie diagrams. More specialised studies, such as human error analysis, may also be required.

As well as considering normal operations, the risk assessment should identify abnormal and emergency situations and the associated, additional or different risk controls that may be required.

2.6 BLADE CLASH ANALYSIS

Blade clash analysis should be carried out as part of, or to feed into, the broader risk assessment as described in 2.5.

Guideline 8: OWCs should carry out a blade clash analysis to help optimise the physical design of the WTG and/or establish other design or operational parameters and limits

2.6.1 Aims of blade clash analysis

Blade clash analysis is used to help optimise the physical design of the WTG and/or establish other design or operational parameters and limits, such as metocean conditions or vessel height.

2.6.2 What makes a blade clash analysis

Typically, a blade clash analysis will determine whether a strike is physically possible, and under what conditions. It is essentially an analysis of the geometries and dimensions of vessels and of WTG blades.

The risk assessment (2.5) will then consider how such strikes could occur, i.e. identifying ways in which the controls in place to prevent such strikes (interlocks, procedures, etc.) could fail.

2.6.3 Inputs

Input parameters to consider in the analysis should include, but are not necessarily limited to:

(a) Minimum WTG blade clearance above waterline. This will depend on the geometry of foundations and transition piece as well as of the WTG itself. Additionally:
  - (i) for fixed WTGs, the analysis should allow for the highest astronomical tide (HAT), plus wave and swell height, as these will affect vessel position relative to the WTG.

(b) For floating WTGs, vessels and WTGs will move under tide, wave and swell actions, but not absolutely together. The analysis should allow for platform movement due to wind, wave, swell, tide or current, including all six degrees of freedom: pitch, roll and yaw, heave, surge and sway. It should also allow for the possibility that clearance will change over the operating life of the asset, due to marine growth on the platform.

(c) Positions on the WTG of access gates, W2W/B2W gangways and attachment points, davit cranes, transfer ladders, DP reference points, etc. These will affect where vessels need to be stationed during operations.

(d) Maximum vessel height above waterline (HAW) (also referred to as air draft), taking account of elements of vessel superstructure, including the bridge, W2W/B2W towers and gangways, helicopter decks, crane systems, radio masts, etc. Related factors to take into account include:
  - (i) for cranes, the full range of configurations (boom extension, luffing and slewing).
  - (ii) for travelling/mobile cranes, the range of positions on deck.
  - (iii) the effects of vessel loading and the load lines in use. It will generally be conservative to assume the lightest loading, such that the analysis is based on the vessel sitting at its highest in the water.

(e) Vessel movement in all degrees of freedom, under the vessel's own power or due to wind, wave, swell, tide or current.

(f) Vessel position-keeping ability, e.g. using DP or heave compensation.

(g) Horizontal, as well as vertical, clearance factors, e.g. the vessel outline as seen in plan, and the stand-off distance from the WTG tower/transition piece, as compared with the horizontal distance between the blades and the tower/transition piece.

(h) Geometry of vessel approach and station for different nacelle headings and wind, wave, swell, tide or current directions.

(i) For jack-up vessels, the jacking height.

(j) The head height of persons on the W2W gangway or other parts of the vessel or transfer system. This is a blade strike risk directly to a person rather than to a vessel, and so might not be seen as strictly within the scope of this GPG. However, many of the data and analysis methods will be the same or similar, and the blade clash analysis seems an appropriate place to consider it.

Where metocean parameters, such as wind speed and wave/swell height, are involved in the analysis, judgements will need to be made about what extremes to consider (e.g. return periods for wave height) and what combinations of parameter values to consider (e.g. joint probabilities of wave height and wind direction that would give the smallest clearance). However, maximum wind/wave limits for vessel operation and safe transfer may in practice be the limiting factors for some situations, rather than those based on metocean condition probabilities.

2.6.4 Analysis methods

Commercial 3D modelling software tools that enable clash detection, such as those used for engineering design and building information management, are available to assist with any analysis that goes beyond simple screening calculations. Suitable tools may already be in use by OEMs or other OWCs to support WTG or wind farm design.

2.6.5 Outputs and how to use them

In general terms, the blade clash analysis should identify the combinations of input parameters for which a strike is, or is not, geometrically possible. The analysis should also be able to answer more specific and practical questions. For example, for a given WTG, vessel and metocean conditions, what is the range of headings for which no clash is possible.

Actions informed by the blade clash analysis could include, for example:

- making changes to the physical design of the WTG, e.g. adjusting the number or location of access gates, changing the W2W gangway type;
- selection of different vessels;
- changes to vessel approach orientation;
- setting limits on vessel HAW and other critical dimensions;
- setting metocean limits for operations, e.g. maximum wave height;
- changes to physical design or operations to eliminate or minimise situations in which blades overhang a vessel at any time during operations;
- setting operational limits, e.g. establishing a safety zone for vessels (which could be larger for those with HAW over a certain value), and
- providing information to vessel crews, including what activities and conditions were considered in the blade clash analysis and a diagram of the resulting blade clearance zones. Vessels will have different work positions relative to the WTG depending on the task and other factors, and crews need to understand what was assumed in the analysis in order to be aware of whether they are likely to go outside the safe envelope.

3 GUIDELINES FOR ON-SITE WORK

If the safety by design guidelines in section 2 have been followed appropriately, on-site aspects will be largely a matter of:

- implementing what has been designed (e.g. by commissioning the communications systems and using them as intended);
- adding practical, project-specific details to procedures, etc., that, at the design stage, may have been generic, such as contractor company or vessel details, or names and contacts of key personnel;
- following the procedure(s) developed for vessel approach, and
- the continual improvement cycle of monitoring and evaluating performance and making improvements where needed.

The application of these generic good practices to the specific risk of moving installed blades striking a vessel may not be significantly different from application to any other risks, but the following guidelines identify some key factors to be considered with particular care.

Guideline 9: OWCs should review, refine, update or expand on risk assessments and safety arrangements to allow for factors that could not be fully considered or foreseen in safety by design

Changes may be planned, emergent or due to abnormal and emergency situations. Experience from offshore incidents across the energy and maritime sectors consistently shows that failures in recognising, assessing or controlling change are a recurring contributory factor, particularly where operations move outside the conditions assumed during design and planning.

A robust management of change (MOC) procedure is therefore a critical safety control. This should already be part of the OWC's SMS. Examples of changes relating to the risk of moving installed blades striking a vessel include:

- changes to the OWC's own SMS;
- aligning or making bridging arrangements between the OWC's SMS and the SMSs of vessel operators or other contractors (who may well not have been appointed at the time of the safety by design work);
- changes in the vessels available on the day or other logistics parameters;
- updates to WTG or vessel control and warning systems;
- unexpected changes in environmental conditions;
- unscheduled or unexpected changes in the activities to be carried out on the WTG, e.g. urgent repairs, and
- abnormal and emergency situations.

It is not practicable to foresee all possible situations in detail, so some dynamic risk assessment is likely to be required. Further, as many such changes are likely, almost by definition, to occur at short notice, there may be time pressure, which could impact the level of rigour usually implemented.

The MOC process, therefore, needs to be followed rigorously, ensuring, for example, that there is still proper involvement of all relevant personnel and checking and approval of changes, with escalation beyond the on-site teams and implementation of the stop-work authority as appropriate.

The need for 'on-the-day' review and update of risk assessments, as part of job briefings or toolbox talks, etc., is included as a procedure step in Annex B.

Guideline 10: OWCs should provide frequent updates/refreshers to personnel

Generic arrangements for ensuring training and competence should already be in place, as part of the OWC's SMSs. However, the importance of frequent updates is mentioned here because, especially during the O&M stage, there is typically a lot of shift working, with different external contractors involved and team composition changing frequently. In addition, some personnel may be working on several farms at once, with different procedures on each.

Training should include the 'why' as well as the 'what' of the system design and safety arrangements. Personnel who do not understand the rationale for a procedure, for example, or how the WTGs will behave in different control configurations, may be more prone to error or taking shortcuts. Refreshers and updates can be provided in site inductions or toolbox talks.

4 SUMMARY OF KEY MESSAGES

Key, overarching good practice points are:

– the importance of following safety by design principles;
– ensuring that there are clear and robust procedures for vessel approach and WTG control, including what communications are required at each step, for all foreseeable situations;
– ensuring clarity about who is responsible for what, especially regarding WTG control and who has primacy of control at each stage of the process, and
– ensuring that the parties involved understand the ‘why’ as well as the ‘what’ of the design and safety arrangements.

ANNEX A
COLLATED LIST OF GUIDELINES

Table A.1: List of guidelines

Section/guideline no.	OWCs should…
Section 2 Guidelines – Safety by design	
2.1 Whole-system view	
G.1 Take a whole-system view when developing the wind farm design	
2.2 WTG/vessel access	
G.2 Eliminate or minimise risk through appropriate design of WTG access arrangements and of vessel logistics and approach plans	
2.3 Control, communications and surveillance (CCS)	
G.3 Ensure that the CCS architecture and technologies are designed/selected to maximise functionality, usability, performance, reliability and integrity	
G.4 Ensure that CCS systems are in place as early as possible in the life cycle	
2.4 Procedures	
G.5 Develop procedures defining the steps to be carried out by each party, and the associated communications	
G.6 Ensure that procedures are user focused	
2.5 Risk assessment	
G.7 Ensure that the system design is underpinned and informed by suitable and sufficient risk assessment	
2.6 Blade clash analysis	
G.8 Carry out a blade clash analysis to help optimise the physical design of the WTG and/or establish other design or operational parameters and limits	
Section 3 Guidelines for on-site work	
G.9 Review, refine, update or expand on risk assessments and safety arrangements to allow for factors that could not be fully considered or foreseen in safety by design	
G.10 Provide frequent updates/refreshers to personnel	

ANNEX B
TYPICAL 'ON-THE-DAY' PROCEDURE STEPS FOR VESSEL APPROACH

The steps shown here are purely illustrative and are not necessarily suitable for all situations. There may be variations in the nature and order of the steps, depending on factors such as the nature of the work to be carried out, whether personnel are already on the WTG, the WTG status and configuration at the start of the activity, and the available control and communication modes. OWCs should not, therefore, simply copy the content into their own procedures, but should consider each specific project, operation and context thoroughly.

Table B.1: Vessel approach 'on-the-day' procedure steps

No.	Procedure step	Comments
1	Work planning	Procedure should state who does what in identifying and communicating the locations at which work is to be conducted on the day
2	Request, review, authorise and issue prior permissions, permits to work, etc.	Procedures should cover both scheduled and unscheduled work The procedure and any request form should state the notice periods required and what information is to be provided Different permit procedures may be needed for repetitive (routine) operations, (other) scenarios in which the same permit will be used over several days, and 'one-offs'
3	'On-the-day' review and update of the risk assessment, as part of job briefings/toolbox talks, etc.	This is in addition to the hazard identification and risk assessment and management that should already have been carried out iteratively with the design process (including the design of the procedures themselves), as part of the safety by design process – see 2.5. It is important because there may be changes and unforeseen factors on the day, and because there are likely to be personnel on the job who have not been involved before
4	Set the nacelle heading and, if required, the rotational position of the blades	See 2.2 under 'Setting and holding the WTG in position for vessel approach'
5	Hold WTG nacelle (and blades if required) in the required positions	See 2.2 under 'Setting and holding the WTG in position for vessel approach' Procedures should help to ensure that all parties are aware of the implications of the method of holding the WTG in position and take steps to ensure safe operation, e.g. by checking to avoid inadvertent release Note: Although outside the scope of this GPG, as it is not a blade/vessel strike issue, it is important to be aware that there are serious risks to personnel working on a WTG if it is not under effective protection (e.g. local control with lock-out/tag-out) against inadvertent energisation, nacelle yaw, hub rotation, etc. Procedures (and design) should take such risks into account as well as blade/vessel strike

Table B.1: Vessel approach 'on-the-day' procedure steps (continued)

No.	Procedure step	Comments
6	Communicate WTG status, control, nacelle heading and rotor position to the vessel	The vessel crew will need to know whether the WTG is operational, idling, positioned for vessel approach, etc., who has control of it, and the nacelle and rotor positions. Any changes in these factors should be communicated immediately to vessel crews and personnel on the WTG
7	Checks during vessel approach	There needs to be a clear, common and confirmed understanding between control location(s) and vessel crews about which WTG is to be approached and whether it is in a safe state. The procedure should specify who carries out what checks, against what has been defined in the work plan (Step 1) and at what stage in the process. Checking could be by, e.g., automated systems, visually or by verbal/written confirmation
8	Handovers of control	Procedures should cover the various different situations in which WTG control may need to be handed over. For example: – WTG personnel have been transferred on to the WTG and are ready to take local control of the WTG – WTG personnel are ready to leave the WTG and to hand back control of the WTG to a remote centre – Vessel has left the safety zone Depending on the situation, handovers could occur either before or after positioning of the rotor and blades
9	WTG activities, e.g. crane operations, transfer of maintenance technicians to WTG	Procedures should state what checks, etc., should be carried out while the vessel is in position at the WTG, e.g. vessel crew to monitor for any unexpected WTG movements
10	Completion of WTG activities Unlock, reposition and re-energise the WTG	-
11	Close/complete/cancel permits	-
12	Contingencies for abnormal and emergency situations	A few examples of situations for which procedures should be available are shown in Annex C

ANNEX C
EXAMPLES OF CAUSAL/CONTRIBUTORY FACTORS TO THE RISK OF MOVING INSTALLED BLADES STRIKING A VESSEL

As noted in 2.5, many different failures, errors or external conditions may cause or contribute to this risk.

This annex lists a few potential causes and contributory factors identified from incidents to date and example risk assessments, procedures, etc., provided by WG members. This is a starting point, and by no means a comprehensive checklist, nor a failure analysis that, for example, distinguishes between root causes/latent failures and how they may be manifested 'on the day'. One potential application is to use it as a baseline for developing prompts or keywords to apply to each task in a HAZID workshop.

Procedures

- gaps or weaknesses in procedures, e.g., lack of clarity about who has primacy of control at any time;
- procedures unduly complex or difficult to follow, leading to misunderstandings, loss of confidence in the SMS and taking shortcuts;
- insufficient definition of communications required between parties, and
- procedures not kept up to date and appropriate to changes in operations.

Example incidents related to communications, WTG control and procedures

1. The vessel that had asked for the WTG to be locked was delayed in arriving by about one hour. Meanwhile, a second vessel arrived, completed its work and told control that the WTG could be put back into production. When the original vessel arrived, the crew noticed that the yaw angle had changed, although it had been confirmed to them as locked. Fortunately, the vessel crew queried this and did not approach closer.
2. A vessel crew member spotted that the WTG was moving when about 70 m away and stopped their approach. The confusion arose when the original heading request was closed for a new heading request. The shift supervisor then contacted the vessel, informing them that it was clear to approach. The supervisor had not been aware that the original request had been closed and therefore assumed the WTG status was the same as per the original request. The procedure stated that the vessel bridge should be the ones who contact the WTG control to request a heading and receive confirmation. The shift supervisor had added another communication chain link between the vessel bridge and the WTG control.

Human performance and error

System factors, such as a weak safety culture, excessive workload, time pressure and competing goals/priorities, as well as poorly designed procedures and human-machine interactions, will tend to increase the likelihood of unsafe attitudes, behaviours and errors. Examples of the problems that can result include:

- insufficient communication or teamwork between or within vessel crew, personnel on the WTG and control centre or site coordination teams;
- procedures not followed as intended;

- misidentification of the WTG to be shut down/re-energised;
- error in requested nacelle heading or rotor position;
- cross-checks and confirmations not performed;
- distraction by non-navigational tasks, such as administration, of vessel crew responsible for watchkeeping and safe navigation;
- loss of situational awareness;
- competencies not appropriate to tasks;
- insufficient site-specific inductions/training;
- inadequate handover between teams, e.g. at a shift change, or a handover of control between a remote centre and local control by technicians on the WTG, and
- use of verbal agreement/authorisation only, with attendant risks such as misunderstanding/forgetting, or omitting key parties from the communication.

Assets and equipment

- loss of or degraded communication;
- grid outage, which could disrupt CCS, WTG operations or unexpectedly release brakes;
- incorrect WTG status indications to vessel crews, technicians or control centres, and
- WTG control system/SCADA failure.

Operational and physical environment

- SIMOPs – failures of interactions/communications between those attending the WTG and other wind farm operations;
- non-wind farm vessels entering or transiting the wind farm, with or without authorisation;
- loss of vessel DP, power or control;
- metocean conditions, such as visibility, wind, wave and swell, tides, other currents, water temperature, and
- a 'dead' or jammed WTG, which cannot be positioned and/or held in the required position.

Abnormal and emergency situations, such as:

- cybersecurity breach, and
- medical or other emergency evacuation from a WTG.

ANNEX D
ABBREVIATIONS AND ACRONYMS

AIS	automatic identification system
B2W	bring-to-work
CCS	control, communications and surveillance
CTV	crew transfer vessel
CCTV	closed circuit television
DP	dynamic positioning
EI	Energy Institute
FMEA	failure modes and effects analysis
G+	G+ Global Offshore Wind Health and Safety Organisation
GPG	good practice guidelines
HAT	highest astronomical tide
HAW	height above waterline (also referred to as air draft)
HAZID	structured hazard identification
H&S	health and safety
IMCA	International Marine Contractors Association
IMO	International Maritime Organization
MOC	management of change
O&M	operations and maintenance
OEM	original equipment manufacturer
ORED	offshore renewable energy developer
OWC	offshore wind company (see Terminology)
ROV	remotely operated vehicle/vessel
SCADA	supervisory control and data acquisition
SIMOPs	simultaneous operations
SMCP	standard marine communication phrases
SMS	safety management system
WTG	wind turbine generator
W2W	walk to work
WG	working group

ANNEX E
IMPLEMENTATION CHECKLIST

Table E.1 provides a simplified checklist to support users in applying the guidelines. For the full self-assessment tool, refer to EI3617-1 *Managing the risk of moving installed WTG blades striking a vessel – Self-assessment tool*.

Table E.1: Managing WTG blade strike checklist

		Status			
Item	Question	Not assessed	No	Partial	Yes
G.1	Take a whole-system view when developing the wind farm design				
G.2	Eliminate or minimise risk through appropriate design of WTG access arrangements and of vessel logistics and approach plans				
G.3	Ensure that the CCS architecture and technologies are designed/selected to maximise functionality, usability, performance, reliability and integrity				
G.4	Ensure that CCS systems are in place as early as possible in the life cycle				
G.5	Develop procedures defining the steps to be carried out by each party, and the associated communications				
G.6	Ensure that procedures are user-focused				
G.7	Ensure that the system design is underpinned and informed by suitable and sufficient risk assessment				
G.8	Carry out a blade clash analysis to help optimise the physical design of the WTG and/or establish other design or operational parameters and limits				
G.9	Review, refine, update or expand on risk assessments and safety arrangements to allow for factors that could not be fully considered or foreseen in safety by design				
G.10	Provide frequent updates/refreshers to personnel				

ANNEX F
REFERENCES

Please refer to the latest versions of all documents/webpages listed below.

EI Toolbox incident reports

Nacelle yaws automatically during vessel approach | Toolbox (energyinst.org) (published 18 January 2021)

Poor pre-task planning results in turbine blade contacting adjacent vessel | Toolbox (energyinst.org) (published 29 December 2021)

Turbine blade strikes gangway, tipping it into the sea | Toolbox (energyinst.org) (published 18 January 2021)

Miscommunication results in incorrect turbine activation, endangering vessel | Toolbox (published 12 May 2021)

The above were last accessed September 2025 from https://toolbox.energyinst.org/

G+

Good Practice Guidelines. https://www.gplusoffshorewind.com/work-programme/workstreams/guidelines

Safety by Design – Good practice guidance for the offshore wind industry. https://www.gplusoffshorewind.com/__data/assets/pdf_file/0010/1542934/GSafeByDesignGPG.pdf

Last accessed September 2025, as the June 2024 edition.

IALA

IALA *Guideline 1162 The marking of offshore man-made structures*. https://www.iala.int/product/g1162/

Last accessed September 2025 as Edition 1.1, December 2021, with editorial corrections July 2022.

Note: This document includes guidelines on lighting and radar/electronic aids to navigation as well as (painted) markings.

IMCA

Yawing of wind turbine nacelle placed ship in line of fire. Safety Flash IMCA SF 25/21, 13 September 2021.

Near miss: vessel approach to wind turbine tower. Safety Flash IMCA SF 10/21, 8 April 2021. 2021. (Two incidents)

The above were last accessed September 2025.

IMO

IMO Standard marine communication phrases

https://www.imo.org/en/ourwork/safety/pages/standardmarinecommunicationphrases.aspx

https://wwwcdn.imo.org/localresources/en/OurWork/Safety/Documents/A.918(22).pdf

Last accessed September 2025, as the November 2001 version.

ANNEX G
BIBLIOGRAPHY

Publications not specifically referred to in the document, but that may be helpful as further reading are listed below. Please refer to the latest versions of all documents.

EI

Guidance on management of third-party changes to plant control systems. https://www.energyinst.org/technical/publications/topics/process-safety/guidance-on-management-of-third-party-changes-to-plant-control-systems

Last accessed September 2025, as 1st Edition, December 2018 publication, but an update is understood to be in preparation.

While not specifically about the topic of this GPG, this document includes consideration of the risks involved with remote access, predominantly from a data/cybersecurity perspective.

G+

Work programme. https://www.gplusoffshorewind.com/work-programme. Last viewed September 2025 includes:

Good practice guidelines. https://www.gplusoffshorewind.com/work-programme/workstreams/guidelines. This includes GPGs on a range of topics that may interact with the present GPG, such as offshore wind farm transfer, dropped loads, small service vessels, marine coordination and a floating offshore wind HAZID.

Safe by Design workshops. https://www.gplusoffshorewind.com/work-programme/workstreams/workshops. This includes GPGs on a range of topics that may interact with the present GPG, such as marine transfer and access, WTG access and egress, WTG access to transition piece, and floating offshore wind – transfers, access and egress.

G+/IMCA in partnership with Energy Institute

Walk to work workshop. https://www.gplusoffshorewind.com/?a=1698883

Last accessed September 2025.

IMCA

IMCA HSS025/IMCA LR 012/IMCA M 202 *Guidance on the transfer of personnel to and from offshore vessels and structures*. https://www.imca-int.com/product/guidance-on-the-transfer-of-personnel-to-and-from-offshore-vessels-and-structures/

Last accessed September 2025 as Rev 2.2, March 2024.

IMCA M254 *Guidelines for walk to work operations*. https://www.imca-int.com/resources/technical-library/document/8bc53e5f-c55b-ee11-8def-6045bdd0ef2e/

Last accessed September 2025 as Rev 1, August 2025.

UK HSE

Risk of collision with offshore installations from attendant vessels. Health and Safety Executive – Safety notice. Bulletin number: ED01-2025. Risk of collision with offshore installations from attendant vessels - HSE. Last accessed September 2025 as issue date March 2025.

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