International Association of Drilling Contractors

North Sea Chapter

SHIP COLLISION: RISK OF STRUCTURAL FAILURE

Guidance on MODU/MOU Safety Case Content

Contents

Revision	Amendment	Date

1. Abbreviations

Abbreviation	Description
ALARP	As Low As Reasonably Practicable
COMOPs	Combined Operations
DP	Dynamic Positioning
ERRV	Emergency Response and Rescue Vessel
FMEA	Failure Mode & Effect Analysis
GOMO	Guidelines for Offshore Marine Operations
HSE	UK Health and Safety Executive
IADC	International Association of Drilling Contractors
MAH	Major Accident Hazard
MJ	Mega Joules (collision energy)
MODU	Mobile Offshore Drilling Unit
MOU	Mobile Offshore Unit
NSC	North Sea Chapter
OSDR	Offshore Safety Directive Regulator
PPE	Personal Protective Equipment
TVI	Tolerable Velocity of Impact
UKCS	United Kingdom Continental Shelf

2. INTRODUCTION

This guidance on structural failures due to ship collision has been developed by an International Association of Drilling Contractors (IADC) North Sea Chapter (NSC) Work Group. The document has been prepared in response to the Safety Executive (HSE) letter of 19th September 2018 [Ref. 0], it also incorporates amendments and feedback provided by NSC members and includes input from the HSE. This document describes and provides guidance that could be used to assist IADC North Sea Chapter members (duty holders) in assessing and mitigating against structural failures resulting from ship collisions as part of a safety case submission, and when developing their management systems with respect to ship collision. This document does not cover technical analysis of collision impact, that is for members to undertake, but it does give guidance on what to consider when undertaking that analysis.

The consequences of a ship collision vary depending on the location and type of drilling installation. Jack-up installations are more susceptible to catastrophic structural failure due to ship collision, as a collision with a leg could cause the installation to collapse. Drillships and semi-submersible installations are less likely to catastrophically fail, as they are not fixed in position so can move when impacted, or even avoid ship collision altogether. Therefore, the primary focus of this document is on minimising the risk of ship collision with Jack-up legs, but the management principles are equally applicable to Semi-Subs and Drillships.

To assess the risk from ship collisions, a collision energy value of 14MJ has historically been used to represent a collision of a 5000 tonne vessel at a speed of 4 knots [Ref. 2 & 3]. This value is typically used to represent a bounding value of collision energy which an installation could withstand without failure leading to fatalities. As vessels visiting installations are tending to increase in size and displacement and can be up to 15,000 tones [Ref 2], risk assessments should be updated to account for this, with risk reduction measures implemented if required.

Reference is made throughout this guidance to industry codes, standards and guidance and there is an expectation from the HSE that duty holders should follow the principles set out in them. This should not be interpreted as conferring any status to such material in terms of achieving legislative compliance and does not guarantee a duty holder will comply with the regulations or provide all the information required of them.

3. RELEVANT LEGISLATION AND GUIDANCE

This section lists relevant guidance and provides a summary of the information relevant to the analysis of ship collisions included in each document.

3.1 The Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015

The primary aim of SCR 2015 [Ref. 4] is to reduce the risks from major accident hazards to the health and safety of the workforce employed on offshore installations or in connected activities. The Regulations also aim to increase the protection of the marine environment and coastal economies against pollution and ensure improved response mechanisms in the event of such an incident.

3.2 Oil and Gas UK, Guidelines for Ship/Installation Collision Avoidance

The Oil and Gas UK guidelines [Ref. 5] focus on reducing the major accident hazard (MAH) risk of collision between ships and offshore installations.

Three vessels types are considered:

- Passing vessels – vessels en-route to somewhere other than the installation;
- Attendant vessels – vessels whose purpose require visiting the installation; and
- Offtake tankers – a specific type of attendant vessel.

The guidelines contain checklists covering management systems, vessel suitability, self-audit and pre-operational checks.

3.3 Offshore Safety Directive Regulator (OSDR) Letter: Major Accident Hazard – Potential for Structural Failure of Offshore Installation Due to Collision with Attending Vessels

OSDR published a letter in 2018 [Ref. 9] which recommends that duty holders should be encouraged to:

1. Review the structural capacity of their offshore installations with regard to vessel impact.
2. Consider if they have properly applied the hierarchy of risk control to prevent and mitigate the major accident hazard of structural failure due to vessel collision. This should incorporate safety critical task analysis and human error analysis.
3. Ensure safety cases are revised where necessary.
4. Ensure combined operations arrangements fully consider the requirements of each installation involved to prevent and mitigate risks of structural failure from vessel collision.

3.4 Marine Safety Forum, Guidelines for Offshore Marine Operations

The Guidelines for Offshore Marine Operations (GOMO) [Ref. 6] provide guidance on many aspects of offshore operations. Collision risk management is considered with reference to a number of procedural controls. Aspects covered include:

- Bridge Team Organisation and Management
- Selection of Station Keeping Method
- Pre-Entry Check Lists

- Change of Control Station or Operating Mode
- Setting Up Before Moving Alongside
- Use of Dynamic Positioning
- In Operating Position
- Change of Operating Location
- Weather Side Working
- Requests to Stand-By for Further Instructions, etc
- Extended/Protracted Cargo Handling Operations
- Departure and Commencement of Passage
- Field Transits

3.5 Marine Safety Forum, Guidelines for Offshore Marine Operations: UKCS Supplement

The GOMO United Kingdom Continental Shelf (UKCS) Supplement [Ref. 7] provides guidance for vessels servicing and supporting offshore facilities operating in the UK Continental Shelf with the aim of reducing risks associated with these operations. Guidance provided includes aspects regarding adverse weather working conditions for supply vessels and criteria for response and rescue support, MOU moving operations and FPSO operations.

The guidance document also contains details of a number of UKCS legislation and best practices including operations in the 500m zone and emergency response and rescue vessel (ERRV) survey and management guidelines.

3.6 Step Change in Safety, Marine Operations: 500m Safety Zone

The Marine Operations: 500m Safety Zone [Ref. 2] was prepared together with the Marine Safety Forum and is aimed at providing the offshore workforce with a better understanding of the hazards involved in offshore marine operations. It also provides an insight into how installations and vessels can work together to ensure safer marine operations within the 500m zone.

4. SUMMARY OF MAIN REQUIREMENTS FOR ATTENDANT VESSELS

Risks regarding vessel impact at offshore facilities must be thoroughly assessed and properly managed as outlined in the guidance documents listed above. Duty holders should ensure that installations and procedures are designed to maintain a margin of safety against collapse in the event of a collision with a vessel. There should be consideration of events which could cause global failure of the structure, local failure leading to global failure and failure of a system which could lead to a more significant consequence for the failure.

In addition, procedures should be in place as part of the risk management of vessel collision. Procedures should ensure that any local factors are included which have the potential to impact risk reduction measures.

5. SHIP COLLISION RISK ASSESSMENT REQUIREMENTS OVERVIEW

This section provides an overview of typical technical considerations that would be expected to be in place for installations regarding ship collision. The items listed below should be considered within the hierarchy of risk control.

To determine the specific installation requirements, a technical / quantitative risk assessment should be carried out. Though the methodology of such assessments may vary, it will include considerations such as:

- Location – The location of the facility is reviewed and its proximity to shipping lanes determined as part of installation consent to locate. This considers the passing vessel potential. For Jack-Up installations other factors such as soil characteristics, water depth, air gap may also need to be considered and these elements may present difficulties in establishing a definitive structural capacity for the installation.

  Duty holders should however set a limit based on certain assumptions which as long as they can operate with these conditions they will be within a safe limit for the installation. If they choose to go outside these assumptions, further assessment may be considered as part of the risk management strategy.

- Facility Withstand Capability – The withstand capability of the facility is to be determined. This may be available from original design documentation or a specific quantitative study may be required, as the historically used value of 14MJ may not be conservative. Commercially available finite element analysis software, such as Bentley SACS [Ref. 8], can be used to calculate an installation-specific withstand capability.

- Detailed Vessel Analysis – The number and type of vessels is identified to determine potential displacement. The displacement of the vessel is used in assessing the impact resistance capacity and survivability.

The overall aim of the risk assessment is to consider which vessels and scenarios could result in exceeding the withstand capacity of the facility. A critical collision frequency can be determined, and this can be used to focus risk reduction measures. However, the focus of the assessment should be about minimising the risk gap to ALARP i.e. establishing the installation impact capacity; relating that to a critical vessel displacement; comparing the minimum vessel displacement required for the task; implementing appropriate additional measures.

With the recent trend of increasing vessel sizes and displacements it is generally recommended that additional controls are considered where vessel size is in excess of 5,000 tonne displacement due to the increased potential impact energy (see **Table 1**). Larger vessels could result in the potential to exceed the withstand capability of the installation's structure for some vessel approach headings and prevailing sea conditions.

Table 1: Vessel Impact Energies [Ref. 2]

Vessel Displacement (tonnes)	Vessel Speed (m/s, *knots)*	Impact Energy (MJ)	
		Bow/Stern on	Side (beam) on
2,000	0.5, *1*	0.28	0.35
5,000	0.5, *1*	0.69	0.88
5,000	2, *4*	11	14
10,000	2, *4*	22	28

Further detailed assessment can also be carried out; the Tolerable Velocity of Impact (TVI) can be determined that will not affect the integrity of the installation in both floating conditions and jacked up condition for bow, stern and broadside impact.

The TVI and outline information about the likely damage for bow, stern and broadside impact in floating condition and jacked up condition. This information should be provided for different water depths. Additional structural modelling may be needed to determine this based on exact jack-up operation and attendant vessels.

Note: It is recommended that a velocity of no less than 2.0m/s should be used in the assessment to represent a high energy collision in an accidental condition.

6. SHIP COLLISION RISK MANAGEMENT REQUIREMENTS

This hierarchy of controls shows a number of methods for reducing risks through the following prompts: eliminate, substitute, engineered controls, procedural controls and personal protective equipment (PPE). The prompts are listed from the most effective controls to least effective controls.

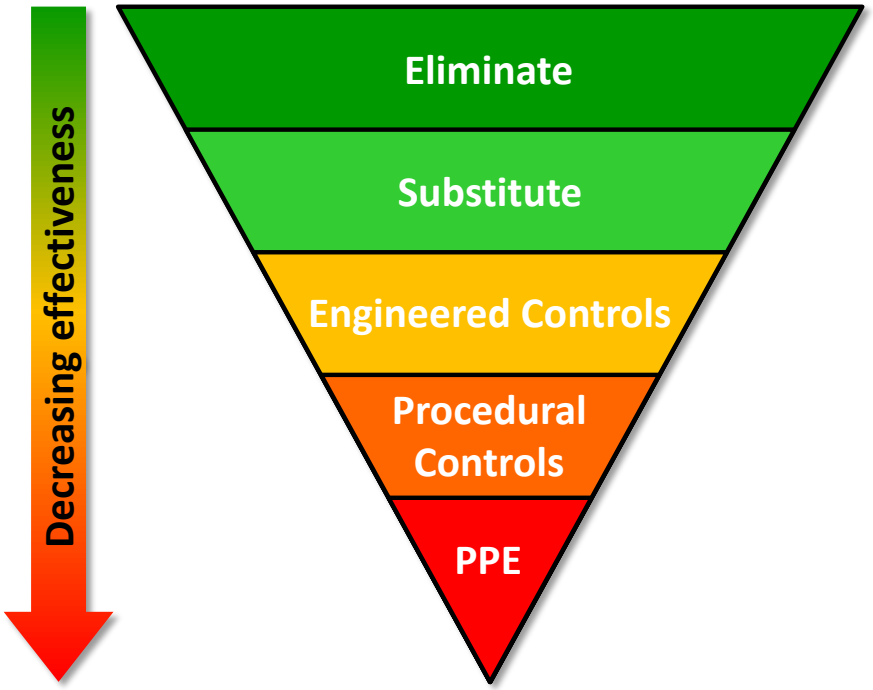

Figure 1: Hierarchy of Controls

When assessing potential risk reduction measures, those which eliminate the risk altogether should be prioritised. If the risk cannot be eliminated, focus should next be on measures which combat the risk at source. For example, redesign or guarding, an engineered safeguard, or restricting vessel movements in the area or a procedural control.

Measures which reduce risk by relying on human behaviour tend to be less effective and reliable, for example working procedures and use of PPE.

The following shows examples of how risk can be reduced during attendant vessel selection using prompts in line with the major hazard hierarchy of controls:

- Eliminate – Is there the potential to limit the vessel requirements at the facility
- Substitute – Is there scope to use smaller vessels? Use of smaller vessels to be discussed with the Operator
- Engineered Controls – The use of a higher specification vessel to remove risks should be considered
- Procedural Controls – Use of additional or restricted working practices and mitigation to reduce risk of collisions. Additional triggers can be built into 500m zone checklist as per Step Change in Safety guidance [Ref. 2]. Is it practicable to only allow vessel approaching into the weather in blow off conditions?

The hierarchy of controls is a useful tool to demonstrate that risks are ALARP, as considering risk reduction measures in this way provides a structure to the review process that can be clearly documented and is widely accepted.

6.1 Management System Aspects

Once a facility is designed, built and operating, there is often most scope for risk reduction measures in procedural controls.

There are typical controls that are expected to be in place for all vessel operations within the 500m zone as outlined in various industry guidance [Refs. 2, 5, 6, 7]. Procedures for vessel operations should consider:

- Vessel selection – It is understood that drilling contractor duty holders often have vessels supplied by production installation operators. However, there is a requirement for both parties to cooperate to ensure the risk presented by vessel impact is effectively managed and it is the drilling contractor duty holder who is ultimately responsible for managing the risks to their own installation
- Marine Assurance Activates - Promote joined up marine assurance activities, or verification with the operator i.e. members representative e.g. Marine Supt attend an annual vessel audit, and / or, operator to share Marine Assurance reports and audits with drilling contractor
- Interface with the Operator on the installation / vessel interfaces - For operations involving larger vessels e.g. Dive Vessel then review of DP FMEA's, station keeping capabilities and crew competency may be required together with an operation specific risk assessment
- Training and Competency of personnel
- Approach, passage and pre-entry - Pre-entry checks include review of vessel displacement, DP capabilities, entry speed and pre-agree working position and approach vector.
- Approach to defined position set up - i.e. 200m from installation
- Weather - consider limiting or restricting weather side working. Operations that may/may not be conducted given the current weather such as hose work, or heavy lifts
- Position set-up - Where additional station keeping checks are carried out prior to installation approach
- Final approach alongside
- Exiting the area

The Marine Responsible Person should ensure that vessel movements are monitored in compliance with industry guidance within the 500m zone.

6.2 Major Accident Hazards

Ship collisions can also be a cause/lead to other MAHs. For example, depending on location of impact and impact energy, collision could lead to loss of well control, or structural failure. A useful tool for assessing MAHs adopted by many duty holders in showing barriers and effective controls is by using bowtie diagrams.

From the bowtie the following areas will be identified to ensure adequate implementation of risk controls;

- Identification of Safety Critical Activities showing controls in preventing/mitigation against for a ship collision event. The following tasks would be expected to be identified with job role carrying out these activities;
    - Marine Competent Person identified for installation risk control on vessel approach.

- Structural Inspection personnel involved in ensuring maintenance of Safety Critical Structural Equipment.
- Tasks expected by the duty holder of the attendant vessel and duty holder assurance of these activities.
- Human Factors impacts considered in the safety critical activities.

- Identification of Safety and Environmental Critical Elements and the management of these whilst outlining process for;
  - Identification of structural maintenance requirements and process for highlighting any deviations that may alter risk profile for attendant vessels.
  - Verification process carried out and process for raising on non-conformity

6.3 Combined Operations

In terms of combined operations (COMOPs) with another installation attendant vessel risk will be reviewed as part of bridging document and COMOPs risk assessments with specific risk assessments for larger vessels undertaken.

It is important to demonstrate that risks are As Low As Reasonably Practicable (ALARP). In order to achieve this, it needs to be shown that minimum acceptance criteria and good practice have been met and that additional risk reduction measures have been considered and implemented where it is considered 'reasonably practicable' to do so.

It should be clear in the Bridging arrangements who is in charge/which guidance takes precedence

6.4 Emergency Response

Collison risk is recognised by industry as a Major Accident Hazard (MAH) as set out above and duty holders should undertake regular exercises that consider such as leg damage, column puncture, loss of essential services (raw water).

7. SUMMARY

It is currently being observed that there is a general increase in the size and displacement of offshore installations' attendant vessels. As a result of this change, additional risk assessment may be required, and subsequently additional risk reduction measures put in place. This guidance document provides useful references and summarises the types of risk assessment that could be carried out to ensure the risks from ship collisions are managed adequately: -

- Review of attending vessel arrangements.
- Avoid vessels working in vulnerable areas.
- Selection and use of vessels of appropriate size.
- Provide personnel training.
- Undertake a human factors analysis of the operation

For COMOPs with another installation, attendant vessel risk should be reviewed as part of a bridging document and COMOPs risk assessments with specific risk assessments for larger vessels undertaken.

8. REFERENCES

1. Offshore Safety Directive Regulator (OSDR), *Letter: Major Accident Hazard – Potential for Structural Failure of Offshore Installation Due to Collision with Attending Vessels*, 19 September 2018
2. Step Change in Safety, *Marine Operations: 500m Safety Zone,* March 2017
3. HSE, *Offshore Division Technical Policy,* http://www.hse.gov.uk/offshore/shipimpact.htm, December 2006
4. HSE, *The Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015*
5. Oil and Gas UK, *Guidelines for Ship/Installation Collision Avoidance,* Issue 2, Feb 2010, ISBN 1 903 003 62 8
6. Marine Safety Forum, *Guideline for Offshore Marine Operations*
7. Marine Safety Forum, *The Guidelines for Offshore Marine Operations: UKCS Supplement*
8. Bentley SACS software https://www.bentley.com/en/products/product-line/offshore-structural-analysis-software/sacs-collapse, accessed December 2018
9. OSDR, *Offshore Marine Operations Inspection Guide, Appendix 2 – Collison Risk Management*

9. APPENDIX – EXAMPLES OF KEY ASPECTS TO INCLUDE IN A SAFETY CASE

Vessel collision consideration should be included in the safety case. The following sections require reference to visiting vessels and potential vessel collisions:

- **Description:**
  Describe arrangements/requirements for attendant vessels (e.g. offshore support vessels, ERRV and dive support vessels).

- **Safety Management System**:
  Describe any procedural control in place, for example any additional controls for vessels within the 500m zone. Include vessel collision in safety critical tasks.

- **Risk Assessment:**
  Include vessel collision risk within the bowtie diagrams where applicable.

- **ALARP Demonstration:**
  Include discussion of vessel collision and the risk reduction measures in place to reduce the risk as part of ALARP demonstration

- **Installation structural capacity against Vessel Impact:**
  - Operational vessel displacement based on the installation capacity, above which additional controls are needed;
  - Summary of the additional controls

- **COMOP notifications should contain:**
  A statement that arrangements have been made to allow each duty holder to comply with the specific vessel impact mitigation measures as outlined in their safety case.