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Introduction

This information sheet provides guidance on compliance with the relevant regulations for assessing the structural response to vessel impact. Duty holders must be able to demonstrate that for all types of offshore installation the risks associated with collision from all attendant vessels have been reduced to as low as reasonably practicable (ALARP).

This sheet deals specifically with HSE's expectations relating to the structural response of the offshore installation to the collision. Guidance relating to reducing the risk of collisions occurring is not included here but may be appropriate to demonstrating an ALARP position has been proven.

Background

Attendant vessels have changed significantly since many of the installations on the UKCS were designed and constructed. In addition to larger supply vessels, walk to work (W2W) vessels are now being used, leading to an increase in the probability and energy of impact.

If vessel movements and marine operations are not effectively controlled, offshore installations are susceptible to collision primarily from

- visiting vessels including supply boats and walk to work vessels
- vessels stationed alongside such as diving support vessels and flotels
- vessels stationed close by such as standby vessels

This sheet does not consider high energy impacts from passing vessels. This risk is mitigated largely through early warning systems rather than relying on the installation structural capacity.

Collision can be caused by

- drifting in wave, wind and current
- operator error or system failure resulting in drive on impact

Impact from vessel collision can cause member failure, partial failure or in extreme cases complete failure of the installation structure. This can impair the temporary refuge (TR) or cause equipment failure. Equipment such as risers, ESD valves, conductors and caissons located in the vicinity of the impact zone are vulnerable to direct vessel impact and can also be damaged by

- failure or partial failure of members supporting or shielding vulnerable equipment. Most risers and some conductors are supported or shielded by legs and braces
- excessive deflection or relative displacements of equipment supports as a result of structural damage
- deck accelerations caused by vessel impact - these can be sufficiently high to cause damage to equipment supports, the equipment itself or its controls

Impact can also damage the buoyancy tanks of floaters or other compliant structures, leading to loss of buoyancy or stability.

Structural and equipment damage caused by vessel impact can escalate into various major accident hazard scenarios.

Legal requirements

The following regulations and associated guidance are relevant to vessel impact

- Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015 Regulation 16(1)(d). Relevant guidance L154 211 & 212
- Offshore Installations and Wells (Design and Construction, etc.) Regulations 1996, Regulation 4(1), 5(1)(a, b & e), 7, 8(1). Relevant guidance L85 38(d), 54 - 58 & 48
- Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations 1995 (PFEER), Regulations 4(1), 5(1), 5(2)(a – d), 9(1)(b). Relevant ACOP and Guidance 42(a), 47, 49(a)(I, ii, v & vi)
- Management of Health and Safety at Work Regulations 1999 Regulation 3(1)

Standards and guidance

Minimum procedures for the assessment of vessel impact capacity are provided in key standards, including ISO 19902:2007[22], ISO 19903:2006[23], ISO 19904[24] and NORSOK N-004[13] which provide consistent recommendations. An overview of vessel collision assessment methods and assessment of the risks, is provided in the Det Norske Veritas Recommended Practice DNV-RP-C204[4] and Lloyds Register document 'Guidance Notes for Collision Analysis'[25].

In 2018 HSE wrote to the industry to raise awareness of the issue. Although the letter was aimed at preventing structural failure of offshore installations due to collision with attending vessels, it was written from a cross discipline perspective. A copy of this letter can be found in Appendix A of this information sheet.

Complying with the legal requirements

General

The risk of vessel collision should be controlled by ensuring that offshore installations are able to retain sufficient structural integrity to withstand vessel collision. There is further discussion below about what that means for both new and existing installations.

1. Important factors to be considered

a. Planned direction of approach of vessels should be used to identify sides and corners that are vulnerable to impact. Direction of waves, wind and current should also be considered for infield vessels stationed outside the exclusion zone.

b. Vulnerable parts of the structure and equipment should be identified by considering the level of water, draft, freeboard, size and shape of vessel, height of bridge or mast and heave and roll for the operating sea state.

c. Consideration should be given to the fact that vessels can drift towards the installation after leaving the exclusion zone.

2. Analysis of the structure

A variety of analysis methods, techniques and short cuts are given in the standards, guides and other references quoted in this document. Duty holders should ensure that the methods they are using are suitable for:

a. the type of installation,

b. relative size of the impacting vessel,

c. relative stiffness' of the contact points – force displacement characteristics given in some of the references quoted may not be applicable in all circumstances.

If appropriate, dynamic characteristics of the structure may have to be considered in order to obtain the lower bound solution for the energy absorbed or tolerable velocity of impact.

In the event of possible damage to the structure or parts of it, the structural analysis should quantify the following in order to provide input to evacuation, escape and rescue (EER) and risk assessment:

d. Extent of damage including loss of members.

e. Magnitudes of local and global deflections, rotations, accelerations and velocities.

HSE recognises the usefulness of suitable simplified techniques in understanding the structural behaviour during impact, and in providing assurance for the validity of more advanced techniques. Detailed finite element analysis may be necessary to refine the lower bound values of energy absorption if justification is required for the use of larger infield vessels, or if impact scenarios are not covered adequately in the guides and references used. However, the results from such advanced methodologies should be validated using suitable simplified techniques.

3. Member failure, local damage

The effect of member failure, local damage or excessive deflection on TR and equipment supported or shielded by them should be considered.

4. Escalation

If any equipment can be damaged, the potential for escalation and possible impairment of emergency and EER systems should be considered in the risk assessment. The structural response to any such escalation should also be assessed and recorded.

5. Safety case

The installation safety case should contain all the relevant details of the vessel impact assessment. The safety case should contain full details of the measures taken to manage vessel impact, including reference to

- structural assessment and consequences of damage or deflections
- marine procedures
- limiting sea states and the assumed drift speed
- other relevant considerations

New installations

6. Design expectations

When designing a new installation, it is expected that the installation is capable of withstanding ship impact loading in accordance with the ISO 19900 series of codes of practice. The vessel displacements used in the analysis should represent the largest vessels intended to be used for regular operations at the offshore installation including supply and walk to work operations. These design assumptions should also contain an allowance for vessel displacement to increase over the life of the installation.

Two types of collision should be considered:

1. Low Energy Impacts – The vessel velocity considered should not be less than 0.5 m/s. As this represents a minor accidental “bump” during normal manoeuvring of the vessel, the assessment should demonstrate a serviceability limit state in which the offshore installation can withstand this impact with no requirement for remedial work.
2. High Energy Impacts - The vessel velocity considered should not be less than 2.0 m/s. As this represents a much rarer condition outside normal manoeuvring of the vessel, the assessment should demonstrate an ultimate limit state in which the offshore installation structure is damaged but progressive collapse shall not occur.

7. Design considerations

When planning new offshore installations, measures should be taken to minimise the likelihood of such collisions occurring. Considerations may include:

a. Loading buoys or similar equipment should be located so that the offtake tankers using them are unlikely to drift towards the installation in the event of power or mooring failure.

b. Loading / unloading cranes and link bridge landings should be located to ensure that supply boats, W2W vessels or flotels are likely to drift away from the installation in case of power or mooring failure.

c. Structural configuration should be robust enough to tolerate local damage including the loss of a brace and maintain global integrity and stability.

d. Safety critical, and equipment essential to EER, should be located and supported so that they are not vulnerable to impact damage.

Existing installations

8. Assessment reviews

Reviews of the vessel impact assessment should be carried out periodically to ensure it remains representative of the conditions encountered. This should include when there are:

a. Changes of ownership.

b. Changes of attendant vessel, particularly when larger displacement vessels are to be used.

c. Damage, deterioration or modification to the installation.

d. Improved / increased understanding, including those incorporated in the revisions of codes and standards.

9. Assessment expectations

HSE expects all offshore installations to comply with the same standards as those set for new installations. However, due to changes in vessel size, technology and operations this may prove impractical.

For existing structures, the following criteria should be used to assess the suitability of the installation to use a particular attendant vessel.

1. Assess the maximum vessel displacement for the installation based on the installation collision energy capacity at a vessel impact velocity of 2.0 m/s;

2. Select a vessel with maximum displacement lower than the calculated maximum displacement for the installation;

IF THIS IS CANNOT BE ACHIEVED

3. Select a vessel with lowest practical displacement to carry out the operation safely and assess the maximum tolerable impact velocity for that displacement;

AND

4. Implement appropriate measures including marine control procedures to reduce the risk of exceeding the maximum tolerable impact velocity to ALARP.

The ISO code highlights the 2.0 m/s velocity limit based on drifting in a significant wave height of approximately 4 m. However there have been incidents of drive on collisions

occurring within the exclusion zone. Reducing the allowable wave height alone for such operations is therefore unlikely to be sufficient as a risk reduction measure.

For further information on what appropriate marine control procedures comprise, contact HSE's Emergency Response, Marine and Aviation Operation (ERMA) specialists.

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23. ISO 19903:2006 Fixed Concrete Offshore Structures
24. ISO 19904:2006 Floating Offshore Structures, Part 1: Monohulls, Semi-submersibles and Spars
25. Lloyd's Register, Guidance Notes for Collision Analysis 2014
26. HSE Letter to Industry: Potential for Structural Failure of Offshore Installations Due to Collision With Attending Vessels, 19 September 2018

Appendix A

HSE Letter to Industry September 2018

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Attn: Trevor Stapleton, Health & Safety Manager

Date: 19 September 2018

Dear Sirs

MAJOR ACCIDENT HAZARD – POTENTIAL FOR STRUCTURAL FAILURE OF OFFSHORE INSTALLATIONS DUE TO COLLISION WITH ATTENDING VESSELS

Structural failure is a major accident hazard for all offshore installations. An outcome from HSE's structural integrity interventions over the last three years revealed a need to increase awareness by refreshing some relevant HSE information sheets that give generic guidance on the topic. Suitable revisions will be published in due course, meantime this letter shares information and draws attention to the main issues. I would be grateful if you could share the letter among your member companies for their awareness. Naturally HSE is happy to engage with your members via any of your relevant group meetings or forums should you wish.

Background

The displacement of vessels attending offshore installations has been increasing through the years since offshore oil and gas operations began in the UKCS. The operations carried out from these vessels has also increased in frequency and scope over that time. The capacity of existing installations to withstand collisions from such vessels has, at best, remained generally unchanged. The unmitigated major accident risk of structural failure due to ship collisions from attending vessels has therefore increased overall. This risk must be controlled through the hierarchy of risk control, in accordance with Schedule 1 of the Management of Health and Safety at Work Regulations 1999 using appropriate measures to safeguard the integrity of installations and protect the offshore workforce.

HSE regularly assists with enquiries about how to manage the hazard and demonstrate within installation safety cases that acceptable controls are in place. We are also aware that client organisations contracting mobile installations need supportive information. The purpose of this letter is to raise awareness of the general vessel impact issue across industry and to highlight HSE's expectations on compliance with the relevant statutory provisions.

Main Legal Requirements

The Health and Safety at Work etc Act 1974 and the Management of Health and Safety at Work Regulations 1999 set out requirements for identifying and assessing risk, and the principles to be adopted to prevent it resulting in harm to persons. The principles are applicable in both major hazard control and occupational safety management.

The Offshore Installations and Wells (Design and Construction, etc) Regulations 1996 [known simply as DCR] impose a general duty under Regulation 4 that requires all duty holders to ensure that an installation at all times possesses such integrity as is reasonably practicable. In relation to vessel collisions, the installation design should be such that it can withstand collision forces acting on it which are reasonably foreseeable. DCR Regulation 7 requires duty holders to ensure that their installations are not operated in such a way as may prejudice their integrity. Risks require to be reduced to as low as is reasonably practical [ALARP].

Regulation 8 of the Offshore Installations (Management and Administration) Regulations 1995 imposes a duty requiring all persons to co-operate with an Offshore Installation Manager [OIM] for certain purposes. It also requires an OIM to co-operate with the OIM of another offshore installation, where an activity carried out from, by means of, or on one of the installations could affect the health and safety of persons on the other installation or of persons engaged in an activity in connection with the other installation. This has important implications for persons involved in selecting and operating vessels to approach and attend an offshore installation. The vessel selected should be suitable in relation to the installation structural capacity and co-operation with the installation manager over this matter is expected. It is particularly important in relation to combined operations between installations and in the selection of vessels suited to approach installations with relatively low structural impact capacity.

The 2005 and 2015 Offshore Installations (Safety Case) Regulations require duty holders to demonstrate how they will comply with the relevant statutory provisions including, but not restricted to those indicated above.

Good Practice for Installation Design and Operation

For all installation types, including mobile offshore drilling units [MODU] and floating installations, HSE regards the requirements of the BS EN ISO 19902 & 19903 codes of practice for Fixed Steel & Concrete Offshore Structures as standards of good practice. These indicate that installations must be capable of withstanding a high energy collision imparted by a vessel of known displacement at a velocity of 2.0 metres per second [m/s]. This event must not lead to the progressive collapse of the installation structure. The impact capacity should be set out in the basis of design of any installation.

The ISO codes base the 2.0m/s criteria on a vessel drifting uncontrolled in a sea state with significant wave height of approximately 4 metres. Besides this possibility, several so-called “drive on” incidents have occurred involving attendant vessels. This risk must also be addressed as even greater collision energies are clearly possible.

Based on the standards, it is HSE’s expectation that for installations currently being designed, the required 2.0 m/s criteria for a realistic vessel displacement will be achieved as a minimum. For some existing installations the 2.0 m/s criteria presents several challenges because of the increasing trend in vessel displacement over the years. It is HSE’s expectation that for such installations the duty holder will determine a maximum vessel displacement at which progressive collapse must not occur from a 2.0 m/s collision.

It should be recognised that as vessel displacement increases, the collision velocity at which structural failure may occur will reduce. A failure velocity lower than 2 m/s, indicates risk levels usually regarded as unacceptable by HSE in regulatory safety case assessments.

Controlling Risk

After assessing collision risk, any measures taken to prevent and protect against it must be taken in accordance with the general principles of prevention set out in Regulation 4 and Schedule 1 of the Management of Health and Safety at Work Regulations 1999. These principles are often termed the hierarchy of control.

Installation duty holders must be able to demonstrate a systematic approach to controlling risk observing this hierarchy and giving preference to implementing the most effective measures. The examples below are for consideration but should not be taken as an exhaustive list:

Avoid the risk:	• Select vessels with displacements accounting for the installation collision capacity; • Prohibit operations in vulnerable areas; • Prohibit weather-side working;
Combat risks at source using engineering controls:	• Strengthen vulnerable parts of the installation and its components. • Select suitable vessels with appropriate equipment to prevent loss of control
Management Arrangements: Use a coherent overall prevention policy which covers technology, organisation of work, working conditions, influence of and relationships between safety critical roles or tasks and the influence of factors relating to the working environment	• Ensure protocols are in place to make certain that vessel equipment is operating correctly prior to approach to an installation and to monitor and control vessel approach and departure safely • Complete a human factors analysis of the operation and the factors affecting its successful outcome (safety critical task analysis and human error analysis); • Adopt safety critical procedural arrangements to reduce the likelihood of and consequence from vessel impact incorporating human factors assessment findings; • Deliver appropriate information incorporating the human factors analysis to all personnel involved; • Ensure all personnel are aware of the identified operational risks and competent in their role to reduce those risks to ALARP.

For further information refer to: The Offshore Installations and Wells (Design and Construction etc.) Regulations 1996 – Regulations 4, 5 & 7

Industry Guidance

Several guidance documents already exist aimed at managing installation/vessel collision risk. Oil and Gas UK published the Guidelines for Ship/Installation Collision Avoidance. This makes further recommendations to reduce the risk of collision and includes a section specifically about attending vessels.

The Guidelines for Offshore Marine Operations (GOMO) should be taken as a minimum standard for all vessels attending offshore installations. Where there is an increased risk due to vessel size and installation capacity, additional mitigation must be implemented.

Step Change published the Marine Operations 500m zone guidance. This provides further information about managing vessels working within 500m of an offshore installation.

All installations have their own unique situation but these documents will assist duty holders develop their own processes to demonstrate they can operate attendant vessels such that the risks of structural collapse from vessel impact has been reduced to ALARP.

Production and Non-Production Installation Safety Cases

The offshore regulatory regime requires installation duty holders to identify major accident hazards. HSE expects that this will include the potential for structural failure due to attendant vessel collision. Risks arising from the hazards must be evaluated and suitable measures implement to control them to an acceptable degree. The duty holder must consider what more could be done to reduce risks to ALARP.

The significant findings of the major hazard identification and risk assessment should be included in the installation safety case. HSE expects this to include details of the capacity of the installation to withstand vessel impact along with the typical displacements of attending vessels used.

The safety case should also provide sufficient details of the range of measures considered to reduce the risk in accordance with the control hierarchy and how appropriate measures are selected and implemented. The level of detail required within the safety case should be commensurate with the extent of risk. For example, it is not necessary to include full detail of marine controls and operations procedures, but assessors expect to see a summary demonstrating how such controls and procedures will achieve safe and effective risk management.

For further information refer to: The Offshore Installations (Offshore Safety Directive) (Safety Case etc) Regulations 2015 – Regulation 16, 17, 18 & 29

Also: HSE Guidance Document L154 paragraphs 216 & 217.

Combined Operations (COMOP) and Co-operation between Duty holders

Attendant vessel operations will occur when offshore installations are engaged in combined operations. Each installation safety case should have identified the potential for vessel collision but it must be reviewed when developing a COMOP regulatory notification. The installation duty holders involved must work together to evaluate any additional risks presented by vessel operations during the combined operation.

One of the installations involved may need more rigorous control arrangements than others to manage the risks arising from vessel collision. Whenever combined operations take place, the installation duty holders involved must recognise the limitations of the other installations and select appropriate attending vessels.

The arrangements for permitting vessels to enter and operate within an installation's 500m safety zone may need to change during combined operations, for example to reflect the requirements of a mobile installation. Duty holders involved have a shared responsibility to ensure this is done effectively. They must consider and agree how entry of vessels in to a safety zone will be authorised, by whom, how it will be communicated to those affected and how approach of vessels will be monitored and controlled. These matters should be detailed in the safety management bridging document for the combined operation

Recommended Action

I trust the above information is clear and can be readily understood among your members, several of whom were informally consulted to assist in its preparation. Please share the letter with your membership and encourage them 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.

HSE will continue to sample compliance with statutory requirements, safety cases, good practice standards and industry guidance. We will also consult as appropriate when proposed revisions to HSE information sheets are available.

If you have any queries relating to the content of this letter you can contact Stewart Millar in the first instance. His email address is stewart.millar@hse.gov.uk.

Yours faithfully

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