Title	Offshore Installation Moorings		
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1.0 Introduction

1.1 This information sheet applies to offshore installation moorings. It replaces OTO 2001/50 on Station keeping; SPC/ENF/50 on the Reporting of Mooring Failures; and incorporates Safety Notice 3-2005 on FPSO (Floating Production Storage and Offloading vessel) mooring inspection, which is now withdrawn. This revision corrects errors found in the published version of Revision 2.

1.2 The guidance is for marine technical authorities and their contractors engaged in design, installation, inspection, and monitoring of mooring systems. It sets out the actions required of duty holders and gives further guidance on offshore installation moorings in the appendices.

1.3 This sheet takes into account the lessons learned from recent mooring failures in the United Kingdom Continental Shelf (UKCS) and reflects the emergence of newer, widely accepted codes and standards. HSE's position is clarified on interpretation of safety case legislation for the UKCS.

1.4 This revision contains revised requirements for mobile offshore units.

2.0 Actions Required

FPSO/FSU/Permanently Moored Installations

2.1 New floating production / storage / permanently moored installations should comply with the technical requirements of ISO 19901-7 Annex B.2.

2.2 Existing floating production / storage / permanently moored installations must be reviewed for compliance with ISO 19901-7 Annex B.2 together with the additional guidance given in Appendix 2 of this sheet. If compliance with ISO 19901-7 Annex B.2 is not reasonably practicable, the duty holder should state in the safety case the reasons for non-compliance and justify the case for safe operation.

Mobile Offshore Units

2.3 For all mobile offshore units, location approvals are expected to meet ISO 19901-7 main text with additional robustness checks for 100-year return period weather conditions as discussed further in appendix 2. Compliance with ISO Annex B.2 is expected if the consequence of a mooring failure is intolerable. In

making such an assessment the factors to be considered include, but are not limited to:

a. Number of personnel on board

b. Proximity to other installations

c. Potential for hydrocarbon release

d. Subsea infrastructure

e. Expected duration on location

f. Effect of thruster failure

g. Any other relevant/location specific hazards

(E.g. a MODU in open water with minimal subsea infrastructure is considered unlikely to require the application of ISO 19901-7 Annex B2, while a mobile offshore unit in close proximity to another installation is considered very likely to require compliance with Annex B2 requirements.)

Operating Limits

2.4 Duty holders should establish appropriate operating limits after a line failure. These limits should consider the stationkeeping performance of the degraded mooring system and the consequences of a further line failure.

Inspection and Maintenance System

2.5 All installations require an inspection and maintenance system for their moorings. This needs to take into account guidance such as Oil and Gas UK Mooring Integrity Guidelines, API RP 2I and API RP 2SM in determining the nature and frequency of the inspection required.

Verification Scheme

2.6 The mooring system is a safety and environmental critical element (SECE) for which a verification scheme is required in accordance with the Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015. Duty holders should also define suitable performance standards for thrusters and the heading control system where they are required for stationkeeping.

This guidance is issued by the Offshore Safety Directive Regulator (OSDR). Following the guidance is not compulsory and you are free to take other action. But if you do follow the guidance you will normally be doing enough to comply with the law. Inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.

Appendix 1: Codes and Standard

1. This appendix gives the reasoning on the HSE recommended code, and comment on other codes and standards. It applies to both floating production / storage / permanent moorings and to moorings for mobile offshore units, except where noted otherwise. For mobile offshore units which operate at a single location for more than 12 months, duty holders must ensure a robust mooring integrity management system is in place.

ISO 19901-7

2. ISO 19901-7 is the recommended code for offshore moorings. Compliance with the technical requirements of Annex B.2 are not mandatory but should be considered by the duty holder based on the type of installation and the level of risk. The following aspects of Annex B.2 are considered important by HSE and should be met where this is reasonably practicable.

    - increased wear and corrosion allowances in splash zone for permanent moorings;
    - assessment of a simultaneous double failure (two-line failure) for permanent moorings; and
    - increased safety factors which take account of the operational state of the installation when connected to risers or when in proximity to other structures. (The use of ‘consequence class’ for critical mooring lines.)

ISO 19901-7: Annex B.2

3. The Norwegian Maritime Directorate (NMD) has issued local regulations, including the ‘Anchoring Regulations of 10 July 2009, No.998’ (NMD 998) concerning positioning and anchoring systems on mobile offshore units. The 2013 version of Annex B.2 of the ISO Code has been updated to reflect in part NMD 998. A Canadian section is included in Annex B, which states the same technical requirements as for Norway.

4. The particular points of difference to the main text, and to other mooring design codes, in ISO 19901-7 Annex B.2, are

    - enhanced test load requirements for drag anchors
    - increased corrosion and wear allowance in the splash zone
    - assessment of a two-line failure case for a 10-year return period storm (permanent and production unit moorings only)
    - assessment of transient motion after line failure for permanent moorings, irrespective of proximity to other installations
    - increased safety factors when operational, and when connected to risers, or when in proximity to other installations (consequence class)
    - 100-year return period storm condition applied (with slightly reduced safety factors) to the mooring systems of mobile offshore units (MOUs). (The main ISO code applies a 5 to 10-year storm for MOUs)
    - additional requirements for drag anchors as further detailed in DNVGL-RP-E301

- a check (accidental limit state (ALS)) on mooring line integrity for a single extreme event (typically a 10 000-year return period, with a safety factor of 1 applied)

Other Standards

5. The following codes and standards are now widely accepted in the offshore industry

   - API RP 2SK
   - DNVGL-OS-E301 (superseded POSMOOR ’96)
   - Lloyds Register Rules for Classification Floating Units at Fixed location – Part 3
   - ABS Rules for Building and Classification of MODUs
   - ABS Rules for Building and Classification of Floating Production Installations
   - DNVGL Noble Denton: 0032/ND *Guidelines for Moorings*

6. Although these codes and standards differ in emphasis and content, they do tend to harmonise with the ISO Code – particularly the agreement on a design environmental return period of 100 years for permanent moorings.

Appendix 2: General Mooring Guidance

1. This appendix gives further information for design, operation, inspection, monitoring and emergency arrangements for offshore mooring systems.

Thruster Assistance – General Requirements

2. Thrusters in a thruster-assisted mooring system are likely to be safety critical components. Where these are identified as safety critical, duty holders should define suitable performance standards for thrusters and, where applicable, heading control systems.

3. On installations with a thruster-assisted mooring system the personnel responsible for the mooring system must be adequately trained and competent in the use of thrusters. Duty holders may need to consider simulator training. Training exercises should include the response to loss of moorings and manual control of thrusters.

Weathervaning Units with Thruster Assistance

4. In adverse weather conditions, incidents have shown that power supplies have been interrupted due to vessel motion and thrusters have tripped or failed to maintain heading.

5. Most existing codes require full or partial failure of the thruster system to be assessed. This is considered as a redundancy check in ISO 19901-7, or referred to as an accidental limit state (ALS) in some other codes.

6. The extent of thruster system failure in the ALS case should be determined from a Failure Mode and Effect Analysis (FMEA). A complete failure of the thruster system (e.g. through a blackout) should be considered.

7. HSE recommends that, as a minimum, permanently moored installations with thruster-assisted mooring should be able to survive a 10-year storm in a blackout (i.e. with loss of all thrusters). This is in addition to the case(s) based on the FMEA analysis currently required by the codes.

8. Suitable guidance on requirements for the FMEA for the thruster system and the power management is contained in outline in ISO 19901-7 and in more detail in DNV-OS-E301 or Lloyds Register Rules for Classification Floating Units at Fixed location – Part 3.

9. Duty holders need to consider what thruster system failures are used as redundancy or ALS cases. Consequences of a thruster system failure may be most severe in installations where thrusters are used primarily to control vessel heading, thereby minimising the environmental loads on the vessel.

Mooring Inspection

10. Premature and unexpected chain wear has occurred on some FPSO / FSU mooring designs close to the termination of the mooring at the turret. Other likely

wear areas are in the thrash zone close to the seabed. Areas of likely wear should be included in any inspection program.

11. Duty holders are expected to identify critical areas of their mooring systems and to have mooring inspection regimes in place in line with guidance such as the Oil and Gas UK *Mooring Integrity Guidelines* in addition to Classification Society requirements where these are applicable.

12. The frequency of inspection should increase with the age of the mooring. API RP 2I gives some guidance on this. DNVGL-RP-E304 gives guidance for the damage assessment of fibre ropes.

13. The duty holder should establish clear acceptance and rejection criteria for the inspection of all mooring components including chain, wire, fibre rope, connectors, buoys and anodes.

Mooring Tension and Position Monitoring

14. The duty holder should measure and record mooring line tensions. Where this is not practicable then suitable arrangements should be in place to verify the integrity of the mooring system and detect a line breakage. Various surveillance systems are discussed in the Oil and Gas UK *Mooring Integrity Guidelines*. Where none of these is practicable, evaluation of mooring tension may be inferred from the positional information. In this case the installation's position must be continuously monitored using suitably reliable systems.

15. These arrangements should be appropriate for the detection and confirmation of a mooring line break at the earliest practicable opportunity.

16. Appropriate arrangements for position and mooring tension monitoring are described in DNVGL-OS-E301.

Response to Line Break Detection

17. Control room operators should have reliable equipment with an alarm that indicates a line breakage. For further information on line break detection systems, refer to the Oil and Gas UK Mooring Integrity Guidelines[1].

18. Appropriate response procedures should be documented and included in the emergency response manual. Practice drills should be carried out.

Data Logging and Operational Performance

19. Data logging of mooring tension is regarded as good practice in UKCS. Vessel positions, motion responses, and environmental conditions should also be similarly recorded with a view to validate system behaviour and identify failure causes.

Adverse Weather Policy

20. For production installations, the adverse weather policy should be guided by the tension and excursion limits of the mooring system. This should be based on the safety factors applied to the mooring system.

Reporting Mooring Failures (this section replaces SPC/ENF/50 which has been withdrawn)

21. Component failures, such as single chain/wires, connector links, fairleads etc., may be reportable under the Offshore Installations and Wells (Design and Construction, etc.) Regulations 1996 (DCR) Regulation 9 'Reporting of danger to an installation'. These failures may be reported to the Offshore Safety Directive Regulator (OSDR) using the process described in Operations Notice 30 http://www.hse.gov.uk/osdr/reporting/incidents-to-osdr.htm. Refer to the guidance on DCR in HSE publication L85, paras 61 and 62, for further information http://www.hse.gov.uk/pubns/books/l85.htm.

22. System failures, where more than one component fails (e.g. two or more mooring lines), are reportable under Regulation 33 of the Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015 using the process described in Operations Notice 30 http://www.hse.gov.uk/osdr/reporting/incidents-to-osdr.htm.

Moorings for Mobile Offshore Units

23. For those mobile offshore units where it is assessed that compliance with ISO 19901-7 Annex B2 is not expected, location-specific mooring analyses should be performed to ISO 19901-7 main text or other equivalent standards. In addition to the location specific analysis to ISO 19901-7 or equivalent, a robustness check should be done for 100-year return period weather conditions to demonstrate a minimum factor of safety of 1.0 in the intact condition. If this is not achievable for any installation with an accepted safety case, a demonstration of robustness under a minimum of 50-year weather conditions may be acceptable on condition that additional measures to reduce the risk of a mooring line failure are implemented. It is expected that the combination of weather used in the analysis will be onerous to assess the worst-case response to demonstrate adequate system robustness.

24. The installation duty holder should ensure that the mooring arrangements for a specific location are suitable for the local conditions and the operations being undertaken.

25. Location-specific mooring analyses should be prepared to demonstrate the suitability of a particular mooring pattern for the specific location, water depth, seabed infrastructure, soil conditions, and nature and duration of the operation.

26. ISO 19901-7 only permits the consideration of line tension adjustments 'for operational reasons and/or in advance of foreseeable environmental events' not 'the modelling of active adjustments of line tension during the analysis of design situations'. This is interpreted as follows:

    - Line manipulations to maintain vessel position etc. in operating cases are permitted provided that tension levels remain below winch stall capacities.

- A reduction in line pretensions in advance of worsening weather or on moving to survival draft is permitted provided a single adjusted spread is used for all environmental load cases.

- Line adjustments (in the analysis) following line failure are not permitted.

27. Where emergency mooring release systems are fitted, these should be capable of operation from a safe location, typically within the temporary refuge, and using systems which do not create an ignition source in the event of a gas release.

28. Mobile offshore unit duty holders should ensure that they have reliable data on the soil conditions for the location, and that the anchor penetration and holding power has been adequately demonstrated.

29. Location specifics including, but not limited to, water depth, surrounding infrastructure and predicted deep anchor embedment will be considered when determining pretension, anchor embedment checks and anchor holding capacity requirements.

30. To confirm anchors are set, mooring lines should be cross tensioned in accordance with the mooring analysis results.

31. It is recommended that suitable means are employed to verify anchor position and anchor embedment such as the use of remotely operated vehicles (ROVs).

Appendix 3: Legal Requirements – OSDR-enforced legislation applicable to mooring systems

- Offshore Installations (Safety Case) Regulations 2005 (SCR05)
- Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015 (SCR2015)
- Offshore Installations and Wells (Design and Construction, etc.) Regulations 1996 (DCR)
- Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations 1995 (PFEER)
- Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 2013 (RIDDOR)
- Provision and Use of Work Equipment Regulations 1998 (PUWER)

References

1. Oil & Gas UK Mooring Integrity Guidelines https://oilandgasuk.co.uk/product/mooring-integrity-guidelines/
2. BS EN ISO 19901-7 Stationkeeping systems for floating offshore structures and MOUs
3. API RP 2SK Design and Analysis of Stationkeeping Systems for Floating Structures
4. API RP 2I In-service Inspection of Mooring Hardware for Floating Structures
5. API RP 2SM Design, Manufacture, Installation, and Maintenance of Synthetic Fibre Ropes for Offshore Mooring
6. DNVGL-OS-E301 Position Mooring
7. DNVGL-RP-E301 Design and Installation of Fluke Anchors
8. DNVGL-RP-E304 Damage Assessment of Fibre Ropes
9. Lloyds Register Rules for Classification Floating Units at Fixed location – Part 3
10. ABS Rules for Building and Classification of MODUs
11. ABS Guide for building and Classification of Floating Production Installations
12. GL Noble Denton: 0032/ND Guidelines for Moorings – Revision 2 December 2015
13. Operations Notice 30 Arrangements for Reporting of Offshore Incidents http://www.hse.gov.uk/osdr/assets/docs/operations-notice-30-reporting-oil-gas-incidents.pdf
14. Assessing compliance with the law in individual cases and the use of good practice www.hse.gov.uk/risk/theory/alarp2.htm