MODU Mooring in Australian Tropical Waters Guideline

australian petroleum production & exploration association limited

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the voice of Australia's oil and gas industry

PREFACE

This guideline has been developed by industry to provide a consistent and common approach to MODU mooring exposed to cyclonic conditions in Australian tropical waters. Industry participants include Oil & Gas Operators through APPEA drilling industry steering group (DISC), MODU mooring contractors through International Association of Drilling Contractors (IADC), mooring equipment and engineering contractors.

The guideline is to be read in conjunction with the NOPSEMA information paper MODU Mooring systems in cyclonic conditions [18], company mooring standards and procedures and well-known industry codes (e.g. API, DNV GL).

DISCLAIMER

CONTRIBUTORS

The authors would like to acknowledge the industry contributors who were instrumental in writing this Guideline:

- Woodside
- Inpex
- Chevron
- Santos
- Deep Sea Mooring
- InterMoor
- Delmar Systems
- DNV GL
- Valaris
- Shell
- Transocean
- Stena Drilling
- Evan Zimmerman

REVIEW & UPDATES

This publication is intended to be a ‘living’ working document with feedback welcomed and incorporated into a regular review process and the guidelines updated where necessary or desirable.

A feedback form to the editorial committee to provide comments, suggestions for additions or changes or new information on the document can be found in Appendix F.

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DOCUMENT REVISION HISTORY

DETAILED REVISION INFORMATION				
Rev	**Description**	**Date**	**Prepared by**	**Approved by**
A	Split document review by Block 1 & 2 Groups.	10/06/2016	APPEA DISC	APPEA DISC
B	Compiled document review by Block 1, Block 2 & DNV GL.	08/07/2016	APPEA DISC	APPEA DISC
0	Final approved version.	01/11/2016	APPEA DISC	APPEA DISC
1	Feedback Form added as Appendix F.	01/04/2017	APPEA DISC	APPEA DISC
2	Revision in accordance with feedback as detailed in Appendix G.	18/12/2019	APPEA DISC	APPEA DISC

1 DEFINITIONS AND ABBREVIATIONS

A1 Definitions

Term	Definition
Close Proximity	Refers to distance between the MODU and surface and/or subsea assets, including areas of health, safety, environmental, and financial significance, which are close enough to be considered a mooring risk. The risk depends on the type/value/manning of asset as well as MODU mooring design certainty and equipment assurance. The distance depends on the mooring risk and company risk tolerance. As a rule of thumb a distance between MODU mooring centre and high value asset of 10km–20km may be considered “Close Proximity”.
Limit State Analysis	Relationship between metocean data return period and mooring factor of safety. The purpose of this data is to estimate the return period (in years) corresponding to mooring failure and/or the return period at which desired factor of safety are met.
Operator	Operator of the MODU as per NOPSEMA definition.
Titleholder	Holder of the exploration or production permit as per NOPSEMA definition.
Self-Propelled / Remote Release MODU	A Self-Propelled MODU equipped with a mooring system which includes a remote release capability enabling the MODU to disconnect from the mooring system and depart its operating location under its own power and navigate to a safe distance from assets and/or approaching weather events. The remote release system may be either acoustically, mechanically or hydraulically actuated. Note that a Remote Release MODU does not necessarily need to have its own propulsion system.

A2 Abbreviations

Abbreviation	Definition
AHV	Anchor Handling Vessel
ALARP	As Low As Reasonably Practical
API	American Petroleum Institute
APPEA	Australian Petroleum Production & Exploration Association
BOD	Basis of Design
BOE/D	Barrels of Oil Equivalent per Day
BOM	Bureau of Meteorology
BOP	Blow Out Preventer
CPT	Cone Penetration Test
DISC	Drilling Industry Steering Committee
DNV GL	Det Norske Veritas Germanischer Lloyd
FAT	Factory Acceptance Test
FOS	Factor of Safety
GOMO	Guidelines for Offshore Marine Operations
IACS	International Association of Classification Societies
IADC	International Association of Drilling Contractors
ICAP	Inspection & Condition Assessment Plan
ISO	International Standards Organisation
JIP	Joint Industry Project
MAE	Major Accident Event
MMATW	MODU Mooring in Australian Tropical Waters
MOC	Management of Change
MODU	Mobile Offshore Drilling Unit
MBL	Minimum Breaking Load
MBS	Minimum Breaking Strength
MPI	Magnetic Particle Inspection
NDT	Non-Destructive Testing

NGI	Norwegian Geotechnical Institute
NOPSEMA	National Offshore Petroleum Safety & Environmental Management Authority
NPV	Net Present Value
NWATW	North West Australian Tropical Waters
OEM	Original Equipment Manufacturer
OHS	Occupational Health and Safety
OPGGS(S)	Offshore Petroleum and Greenhouse Gas Storage (Safety)
OSIG	Offshore Site Investigation and Geotechnics
PCC	Permanent Chain Chaser
PCP	Permanent Chain Pendent
PMITP	Planned Maintenance, Inspection and Test Plan
PMS	Planned Maintenance System
QAQC	Quality Assurance & Quality Control
QRA	Quantitative Risk Assessment
RAO	Response Amplitude Operator
R&D	Research & Development
RCS	Recognised Classification Society
RP	Return Period
ROV	Remotely Operated Vehicle
SAT	Site Acceptance Test
SP/RR	Self-Propelled MODU's equipped with Remote Release mooring systems
SLF	Single Line Failure
SUT	Society for Underwater Technology
UHC	Ultimate Holding Capacity
UV	Ultra-Violet
VDL	Variable Deck Load

A3 Use of Language

Term	Definition
Consider	Refers to risk based mitigation activities identified in this guideline that may be applied when implementing this guideline.
Recommended	Refers to risk based mitigation activities identified in this guideline that ought to be applied when implementing this guideline.
Highly Recommended	Refers to risk based mitigation activities identified in this guideline that ought to be applied when implementing this guideline. Justification should be documented where the recommended activity is not adopted.
May	Compliance is discretionary and is to be considered.
Should	Compliance is discretionary but is recommended.
Shall/Must	Compliance with the requirement is mandatory.

2 INTRODUCTION

Described below is guidance on MODU mooring in Australian tropical waters (MMATW). Due to a loss of station keeping event to a MODU in 2015, and in response to the investigation and NOPSEMA collaboration, APPEA has agreed to produce and publish this guideline to provide greater clarity on mooring a MODU in cyclonic conditions in Australian tropical waters. The purpose of this document is to:

- Provide a consistent approach to mooring design, installation and equipment assurance.
- A framework to improving station keeping reliability and performance in local conditions which are unique to this region.

2.1 How to use this document

This document is intended to be read in conjunction with industry standards, codes and recommended practices such as API and DNV GL and company standards (if applicable).

The document provides recommendations and guidance on MODU mooring risk based on a risk screening process which categorises the MODU mooring risk as either Low, Medium or High (see *Section 3*). Based on the MODU mooring risk category, guidance and recommendations are provided throughout the document under the subheading of 'Risk Based Mitigation Activities'.

Figure 1 shows the intended workflow for MODU mooring assessment.

Appendix E provides guidance on the workflow presented.

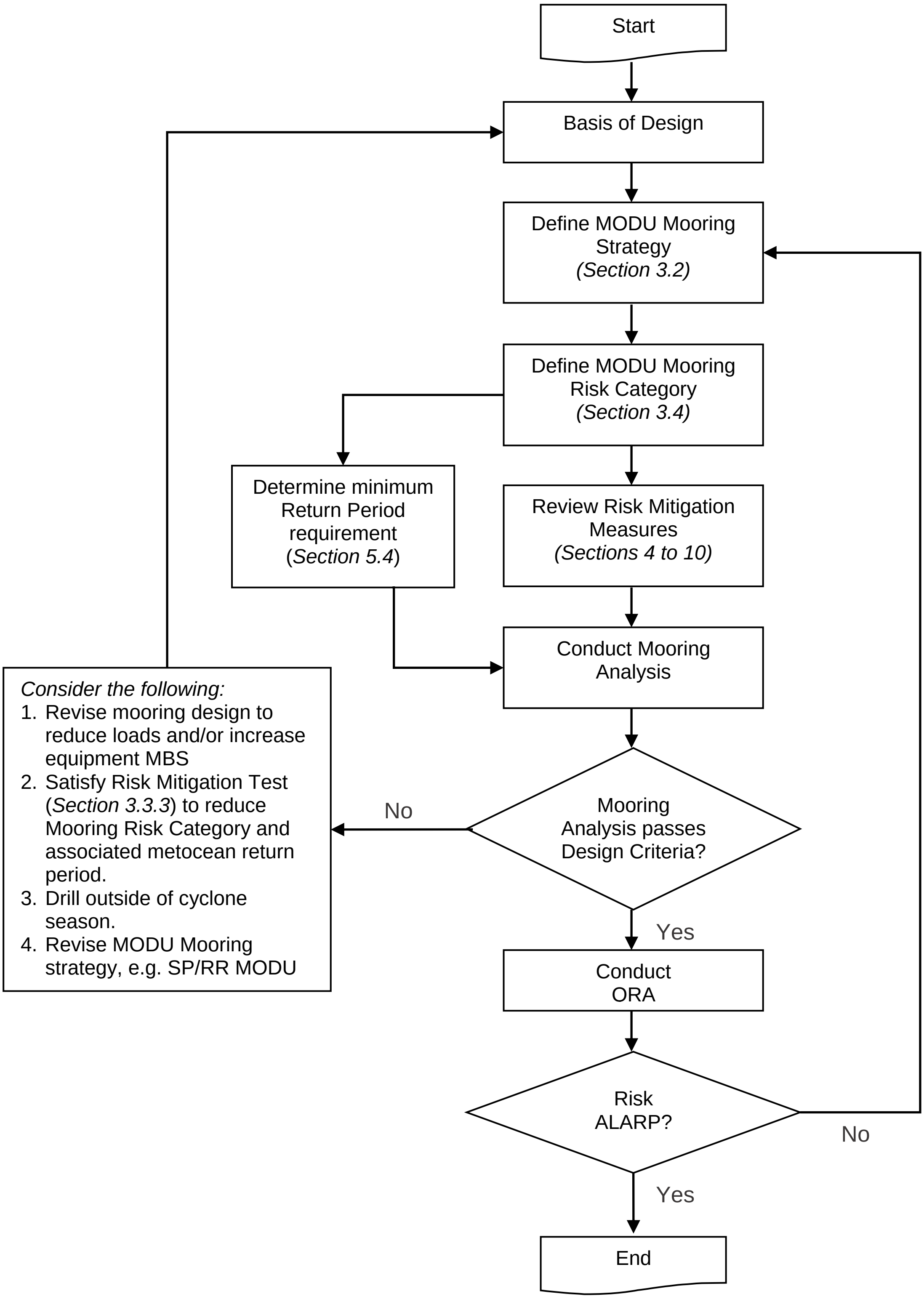

Figure 1: Typical Workflow of MODU Mooring Assessment

2.2 Supporting Mooring Codes and Standards

The primary mooring codes, standards and recommended practices referenced throughout this document are:

- ABS, Guidance Notes on the Application of Fiber Rope for Offshore Mooring, 2011.
- API, Design and Analysis of Stationkeeping Systems for Floating Structures, API RP 2SK (3rd Edition).
- API, Design, Manufacture, Installation and Maintenance of Synthetic Fiber Ropes for Offshore Mooring, API RP 2SM (2nd Edition).
- API, In-service Inspection of Mooring Hardware for Floating Structures, API RP 2I (3rd Edition).
- DNV GL, Position Mooring, DNVGL-OS-E301, July 2018.
- DNV GL, Offshore Mooring Chain, DNVGL-OS-E302, July 2018.
- DNV GL, Offshore Fibre Ropes, DNVGL-OS-E303, July 2015.
- DNV GL, Offshore Mooring Steel Wire Ropes, DNVGL-OS-E304, July 2015.
- DNV GL, Design and Installation of Fluke Anchors, DNVGL-RP-E301, April 2017.
- DNV GL, Damage assessment of Fibre Ropes for Offshore Mooring, DNVGL-RP-E304, September 2019.
- Guidelines for Offshore Marine Operations, March 2019.
- ISO, Specific Requirement for Offshore Structures - Part 7: Stationkeeping Systems for Floating Offshore Structures and Mobile Offshore Units, ISO 19901-7:2013.

3 RISK SCREENING

3.1 Introduction

The purpose of this section is to provide guidance on characterising the MODU mooring strategy during cyclone season and the MODU mooring risk as either: Low, Medium or High. This process is iterative and may be revisited during the design of MODU mooring. The risk-based recommendations throughout this document are based on these three risk categories.

3.2 MODU Mooring Strategy & Risk Screening

There are two MODU mooring strategies that may be adopted during cyclone season to manage the risk of mooring failure. The mooring system can be designed to either:

i. Allow the MODU to remain on location and design the mooring system to withstand cyclonic metocean conditions based on a suitable Return Period. This strategy would normally be employed where the MODU is a conventional barge type moored semi-submersible.

ii. Allow the MODU to release its mooring system using a remotely actuated mooring release system and manoeuvre out of the path of the cyclone. This strategy would normally be employed by a Self-Propelled MODU using a prelaid mooring system which includes an acoustically, mechanically or hydraulically actuated remote release system, i.e. SP/RR type MODU.

Where a SP/RR type MODU is used, the mooring system does not need to be designed to withstand cyclonic metocean conditions. However, detailed planning is required to ensure there is sufficient time available for the MODU to respond to potentially cyclonic metocean conditions and depart the drilling location. Following departure from the drilling location, the MODU's transit speed must be sufficient to allow it to safely manoeuvre away from potentially cyclonic conditions and/or assets.

For conventional moored MODUs, the risk screening comprises three tests:

1. Consequence test – Based on the proximity of MODU (drill site) to high value assets.
2. Likelihood test – Based on season of operation (cyclonic or non-cyclonic)
3. Risk mitigation test – Based on the quality of information available about the MODU, the mooring equipment and the drill site which allows for mooring risk to be mitigated through:
    a. Reliable assessment of mooring load and performance;
    b. Reliable assessment of mooring equipment strength;
    c. Reliable assessment of anchor holding capacity.

For SP/RR type MODUs, the Likelihood Test is not applicable and the MODU mooring risk category is determined by the Consequence & Risk Mitigation Tests only.

The consequence and likelihood tests provide an initial risk category depending on the location of proposed drill centre and season (cyclonic or non-cyclonic). The risk mitigation tests (*Section 3.3.3*) aim to reduce the initial MODU mooring risk category for instances where there is sufficient information available about the proposed drill site and MODU to achieve a high certainty of mooring loads and performance of mooring system.

Changing the risk category for a particular location can be done by changing the season of operation (associated metocean conditions) and/or by satisfying the risk mitigation tests.

3.3 Risk Screening Tests

3.3.1 Consequence Test – Proximity to assets

Is the drill centre in close proximity to high economic or HSE exposure assets?

Guidance: Examples of high value assets in NWS:

- Manned fixed or floating structures for hydrocarbon production (mainly HSE and financial risks)
- Unmanned fixed or floating structures associated with hydrocarbon production (mainly Financial risk)
- Subsea infrastructure associated with hydrocarbon production (mainly Financial risk)
- Active Gas Export trunklines (mainly Financial risk)
- Heritage marine parks and sanctuary zones (mainly Environmental risk)

See *Section A1* for definition of "close proximity".

3.3.2 Likelihood Test – Season of operation

Is the drilling campaign expected to extend into cyclone season? The Likelihood test is only relevant for conventionally moored MODUs where the mooring installation must be designed for cyclonic metocean conditions if the drilling campaign is expected to extend into cyclone season.

Self-Propelled MODUs equipped with Remote Release mooring systems are not required to apply the Likelihood Test as their mooring systems are not required to be designed for cyclonic metocean conditions.

Guidance: Official cyclone season starts from 1 November until 30 April, non-cyclone season is from 1 May to 31 October. However, do note that there have been occasions of cyclones not occurring until mid-November or occurring during the month of May. Appropriate risk assessment shall be carried out to determine the likelihood of such event happening.

3.3.3 Risk Mitigation Tests

Is there enough information about the site and MODU to achieve a high level of certainty that mooring risks can be mitigated to a level that is ALARP? Refer to Section 4.6.3 for guidance on demonstration of ALARP.

Note: All three risk mitigation tests (A, B and C) shall be satisfied.

3.3.3.1 Mitigation Test A – Reliability of mooring analysis

Is metocean data appropriate for location, and have MODU characteristics been accurately determined for a reliable assessment of mooring load and performance?

Guidance: Consider the following:

- ☐ Is site specific metocean data available?
- ☐ Is there sufficient information about MODU characteristics (RAO, force coefficients)?
- ☐ Does the condition of the MODU accurately reflect the tested condition for which MODU characteristics have been determined, i.e. no major modifications to MODU geometry, displacement, mass distribution?

See *Section 5* for more information on MODU mooring analysis considerations.

3.3.3.2 Mitigation Test B – Mooring equipment assurance

Is there a high level of confidence in the mooring equipment Minimum Break Strength (MBS) to assess resistance to mooring loads?

Guidance: Consider the following when evaluating certainty of mooring equipment integrity and MBS:

- ☐ Are original mooring equipment certificates available and traceable?
- ☐ Are service history records and recent inspection reports available for all equipment?
- ☐ Has mooring equipment been inspected after the most recent campaign?
- ☐ Have non-destructive tests been recently carried out for connecting hardware?
- ☐ If wire ropes are not near new, have destruction tests been completed recently?

See Section 8 and Section 9 for more information on mooring equipment and inspection considerations.

3.3.3.3 Mitigation Test C – Reliability of anchor holding capacity

Is there a high level of confidence in the anchor holding capacity to resist mooring loads?

Guidance: Consider the following when evaluating anchor UHC certainty

- ☐ Is there access to site specific soil strength data with information regarding presence and depth of cemented layers?
- ☐ Will an anchor analysis be completed using site specific soil data?
- ☐ Will anchors be proof-tested after installation, either with AHV and/or cross-tensioned with rig winches?

See *Section 7* for more information on geotechnical considerations.

3.4 MODU Mooring Risk Category

Once the above risk screening tests have been reviewed, the below tables can be used to determine the MODU mooring risk category.

		Consequence Test: Is the drill centre in close proximity to high economic or HSE exposure assets?		
		No	**Yes**	
Likelihood Test	**Cyclone season**	**Medium**	**High**	**Medium**
	Non-cyclone season	**Low**	**Medium**	**Low**
			Fail	**Pass**
			Risk Mitigation Test: Have tests A, B and C been satisfied?	

Table 1: MODU Mooring Risk Category – Conventional Moored MODUs

Consequence Test: Is the drill centre in close proximity to high economic or HSE exposure assets?		
No	**Yes**	
Low	**Medium**	**Low**
	Fail	**Pass**
	Risk Mitigation Test: Have tests A, B and C been satisfied?	

Table 2: MODU Mooring Risk Category – Self-Propelled / Remote Release MODUs

4 RISK AND ASSURANCE MANAGEMENT

4.1 Introduction

Mooring design should be risk assessed on a case by case basis either qualitatively or quantitatively depending on the risk level. The mooring system utilised should be associated with a tolerable risk.

4.2 Principles

Risk is defined as:

Risk = Probability (of risk event occurring) × Consequences (associated with that event)

Implementing mitigation activities can reduce the probability of failure (Pf).

The consequences associated with MODU mooring failure can be:

- Health and safety
- Environmental
- Financial
- Corporate reputation and brand
- Legal and compliance
- Social and cultural

4.3 Objectives

The objective of undertaking a mooring risk assessment is to:

- Estimate the likelihood of risk events taking place
- Assess the consequences of risk events
- Rank the risk of the various risk events
- Identify risk reduction options prior to finalising the mooring design and installing the mooring system.
- Confirm that risk associated with major accident event has been reduced to ALARP

Risk events are typically associated with a loss of station keeping, either due to failure of more than one mooring line, or excessive unanticipated anchor dragging, which results in uncontrolled MODU drift. Risk of damage to subsea assets due to mooring line failing and falling though the water column should also be considered.

4.4 Risk Assessment

A suitable risk assessment should be undertaken for a specific MODU mooring operation. The type of risk assessment and associated level of detail depends on the MODU mooring risk category and mooring philosophy with respect to exposure to cyclonic metocean conditions.

For the purpose of this document, risk assessments are characterised as either quantitative or qualitative.

4.4.1 Quantitative Risk Assessment

A Quantitative Risk Assessment (QRA) involves calculating a numerical value for the likelihood (probability) of a risk event taking place through the use of probability theory. The probability is then combined with the consequence to determine the risk.

The probability associated with a risk event is determined by:

- Probability of mooring failure resulting in MODU drift (Pf)

- Probability of impact between MODU and subsea or surface infrastructure (Pi)
- Probability of damage resulting from impact (Pd)

The value consequence of damage including lost production (C)

The risk can then be expressed as:

Risk = Pf x Pi x Pd x C

Additional probability factors can be incorporated into the above equation to account for certainty of: MODU mooring loads, anchor UHC and mooring equipment breaking strength.

Implementing mitigation activities can reduce the probability of failure (Pf).

The advantage of quantifying the probability of a risk event is that it reduces the potential for subjectivity and enables comparison between mooring design options.

4.4.1.1 Required Inputs

In order to undertake a quantitative mooring risk assessment, the following inputs may be required:

- Limit state results from the mooring analysis which consider a wide range of environmental return periods. The limit state results should be plotted (FOS vs RP) for both the anchor holding FOS and mooring line FOS.
- Information on nearby surface and subsea infrastructure:
  - Map which can be used to extract the distance and heading between MODU and nearby infrastructure.
  - Size and construction of pipelines and flowlines.
  - Hydrocarbon throughputs of nearby infrastructure, or in lieu of this, an estimate of the financial consequence associated with collision event between MODU and the infrastructure.
  - Downtime due to repair/replacement and associated cost due to deferred production.
  - Cost of repair or replacement of assets in NPV terms due to potential long lead times.
- Map of important environmental features in close proximity to the MODU location, such as high value marine and shore habitats.
- Source and methodology of metocean data and source of vessel characteristics (certainty of MODU mooring loads).
- Source of geotechnical information and methodology of determining anchor UHC (certainty of anchor UHC).
- Mooring equipment information such as certification, inspection reports, history of use (certainty of mooring equipment MBS).

Significantly high value infrastructure or environmental features which are not in close proximity should also be considered.

4.4.2 Qualitative Risk Assessment

A qualitative risk assessment does not involve the detailed calculation of probability of risk events. However, the likelihood of risk events, and the associated consequence, should still be addressed.

The likelihood can be assessed based on company and local industry experience and historical data.

Probability of mooring failure can be simply estimated by taking the inverse of return period corresponding to the load where failure is expected (from limit state analysis).

Mooring component failure location should also be considered as this affects the possible consequence of mooring failure.

4.5 Risk Evaluation

A convenient method of presenting risk assessment result (qualitative or quantitative) is in the form of a risk matrix. Companies (MODU Operators and Titleholders) will typically have their own risk matrix. Refer to API RP 2SK Appendix K.14.9 [Ref. 1] for more information on risk evaluation and sample risk matrix.

4.6 Risk Treatment

Once the MODU mooring risk is assessed and evaluated, each risk event should then be treated by considering risk acceptance/tolerability, risk reduction and demonstration of ALARP.

4.6.1 Risk Acceptance

Risk acceptance involves determining if the risk is tolerable and if risk reduction measures are required. Individual companies may have their own risk acceptance criteria and limits of tolerability.

4.6.2 Risk Reduction

If a risk is not deemed to be tolerable, or if demonstration of ALARP has not been achieved, risk reduction measures should be identified and evaluated.

Mooring risk reduction measures are listed under the heading of *Risk Based Mitigation Activities* at the end of each section (*Section 4* to *Section 10*) of this document.

Section 3.3.3 Risk Mitigations Tests presents three risk mitigation tests which can be used to reduce the MODU mooring risk category.

4.6.3 Demonstration of ALARP

One of the objectives of the OPGGS(S) Regulations is to ensure that the risks to health and safety of persons at the facilities are reduced to a level that is as low as reasonably practicable [Regulation 1.4(3)]. This is a legislative requirement.

NOPSEMA guidance note (*N-04300-GN0060: The Safety Case Context*) offers a definition of the concept of ALARP [Ref. 17].

“In simple terms, to reduce risk to a level that is ‘as low as is reasonably practicable’ means to adopt available and suitable control measures until a point is reached when the incremental benefit of further risk control measures is outweighed by other issues such as cost, for example, or degree of difficulty of implementing the measure.”

MODU mooring failure resulting in MODU drift can result in a major accident event (MAE). Risks associated with MAEs require demonstration of ALARP.

4.7 Risk Based Mitigation Activities

Risk Based Mitigation Activities – Risk & Assurance Management

Activity No:	Activity Description	Low	Medium	High
4.1	Complete Qualitative Risk Assessment.	HR	HR	HR
4.2	Complete Quantitative Risk Assessment (QRA).	C	R	HR
4.3	Acquire site specific metocean data.	C	R	HR
4.4	Acquire site specific soil data and complete anchor assessment to determine a reliable anchor UHC.	C	R	HR
4.5	Increase anchor proof load test where recommended RP anchor proof load is not achievable and anchor drag risk is high.	NA	C	C
4.6	Install physical protection structures or mats where recommended RP is not achievable and failed mooring lines may impact on subsea infrastructure.	NA	C	C
4.7	Install buoys on lines where recommended RP is not achievable and failed mooring lines may impact on subsea infrastructure.	NA	C	C
4.8	Install fibre rope mooring lines where recommended RP is not achievable and failed mooring lines may impact on subsea infrastructure.	NA	C	C
4.9	Improve certainty of mooring equipment breaking strength (original certificates, inspection reports, non-destructive tests, service history records, etc) See *Sections 8* and *9* for more information.	C	R	HR
4.10	Re-schedule MODU operations outside of cyclone season.	NA	C	C
4.11	Consider use of SS/RR type MODU	NA	C	C

Note: C – Consider, R – Recommended, HR – Highly Recommended, NA – Not Applicable

5 MOORING DESIGN AND ANALYSIS

5.1 Basis of Design Requirements

The mooring system design stage is where design requirements are identified and the technical specifications and performance requirements are defined.

Where complex mooring systems are required there may be a number of organisations involved in the design, provision of equipment, operation and installation & retrieval of the mooring system.

These organisations may include the MODU Operator, the Titleholder, specialist marine engineers, naval architects, mooring equipment suppliers or support vessel operators.

To ensure that there is a common understanding of the requirements of the mooring system and all required data and assumptions are understood and agreed, effective engagement and communication between these organisations is essential.

To achieve the above, a Basis of Design (BOD) should be developed at the earliest stages of the mooring design process and include the following:

i. Scope of Work
    a. General description of work scope (i.e. MODU mooring strategy, applicable mooring system design and equipment design, fabrication & inspection/testing requirements).
    b. Mooring design criteria including the relevant metocean return period and whether cyclonic or non-cyclonic conditions are applicable.
    c. Identification of applicable mooring system design assurance and mooring equipment quality assurance requirements.
    d. Risk assessments including categorisation of mooring risk category (if applicable).
    e. Mooring system Performance Standards (refer *Appendix A*).
    f. Reporting requirements, must be clear on what the deliverable is.

ii. Design Considerations
    a. Applicable design standards and codes.
    b. Under the design criteria category, add the maximum MODU offsets (drilling suspension, disconnect) as per Dynamic Riser Operability Study.
    c. Location of drill centre, “safe handling” location, cyclone “survival” location (if operating during cyclone season) and information on any nearby surface and subsea infrastructure.
    d. Horizontal & vertical clearances between mooring equipment and nearby surface and subsea infrastructure.
    e. Anchor installation tolerance.
    f. Proof load testing requirements for the installed mooring system.

iii. Equipment & Inspection
    a. Specification of MODU and third party specialist mooring equipment (if applicable) and winch capacities, vessel GA, elevation drawings, fairlead locations, on-vessel mooring equipment in addition to the hydrodynamic characteristics.
    b. MODU hydrodynamic characteristics (RAOs, QTFs, wind, wave drift and current force coefficients, etc). These values should be up to date and applicable to the specific water depth.

c. Fibre rope ICAP where fibre rope mooring systems are required.
d. Mooring equipment maintenance, inspection, testing & material certification requirements.

iv. Geospatial
   a. Site survey data (or equivalent) including bathymetry, near seabed soil data and geohazards (no-go areas) identification.

v. Metocean
   a. Under the metocean category, specify the maximum design (or survival) conditions (refer to *Section 5.4*), maximum operating conditions
   b. Metocean data for a range of metocean return periods sufficient to complete a mooring system Limit State Analysis.

vi. Geotechnical
   a. Soil geotechnical data for anchor capacity assessment.

The BOD should be formally endorsed by key stakeholders in the mooring design. As a minimum this should include the MODU Operator, the Titleholder and any specialist marine engineering or naval architects involved in the design of the mooring system or the specification of mooring equipment.

Any material changes or deviations from the mooring system BOD should be reviewed, risk assessed and approved by the original endorsers/approvers of the BOD under a documented MOC system.

See *Appendix D* for an example of a mooring BOD form.

5.2 Mooring Design Scope of Work

Under Australia's offshore petroleum industry regulatory system, the design and acceptance of the mooring system is the responsibility of the MODU Operator.

The MODU Operator may sub-contract some or all of the mooring system design work to specialist marine engineers or naval architects and/or incorporate elements of the mooring system design which have been undertaken by the Titleholder.

The scope of the mooring system design should include the following:

i. Define mooring strategy with respect to cyclonic metocean conditions, e.g. utilising conventional moored MODU or SP/RR MODU.
ii. Define mooring layout to accommodate subsea equipment, pipelines and surface facilities.
iii. Define load cases to maximum metocean conditions.
iv. Define type, size, grade, and quantity of mooring line components for a pre-laid system (if required).
v. Define and optimize pretensions of the mooring lines; and determine cross-tensioning values.
vi. Calculate maximum line tensions and anchor loads for all design conditions.
vii. Where applicable, calculate the optimal line tensions for survival conditions and provide a plan that describes how to slacken off tensions from operating to survival conditions in preparation for cyclones (this needs to be determined in conjunction with the MODU operator). Note that depending on the location-specific mooring system design, an existing unbalanced load distribution between the mooring lines could be made worse by inappropriate slackening of all mooring lines. This is particularly the case for asymmetric mooring patterns.
viii. Determine the maximum offsets of the MODU and relevant clearances for intact and one-line-damaged conditions.

ix. Check clearances between mooring lines and MODU and;
- Adjacent mooring lines and risers;
- Subsea equipment and pipelines;
- Surface facilities;
- Seabed (relevant for fibre rope inserts and swivels).

5.2.1 Standards and Codes

In Australian waters, API RP 2SK [Ref. 1] is typically referenced for the purposes of MODU mooring design.

5.2.2 Analysis Approach

Dynamic analysis shall be performed for the mooring design (in frequency domain, or time domain).

5.2.3 Design Criteria

- Strength criteria as per API RP 2SK should be met, as a minimum.
- For operating condition with riser connected, offset criteria as per API RP 16Q, should be met, as a minimum. Or if a site specific riser operability study is available, then its requirements shall be considered.
- Mooring line clearance (horizontal and vertical) criteria as per API RP 2SK, should be met as a minimum.
- If fibre ropes are used, API RP 2SM or DNVGL-OS-E303 should be met.

5.2.4 Analysis Considerations

Mooring analysis should consider the following effects and sensitivities:

i. MODU response sensitivity to wave period. It is recommended to run sensitivity with varying wave period and corresponding significant wave height for the governing load case. Ideally use site specific Tp/Hs contours.

ii. Effect of surge and tide, particularly for shallow water locations.

iii. Anchor installation tolerance, i.e. changes in anchor range and line heading.

iv. Location of mooring centre – e.g. when proposing a survival position or safe handling position, effect of line catenaries, mooring line clearances etc will need to be taken into account as part of the analysis to ensure the proposed location has been designed to ALARP.

v. If fibre ropes are used, the non-linear stiffness of fibre rope should be modelled appropriately. Refer to API RP 2SM for guidance.

vi. Allowance should be made for construction stretch (permanent elongation) of fibre rope caused by maximum historical load. Refer to API RP 2SM for guidance. It should be particularly noted that axial stiffness of as-new polyester ropes is much lower than in post-installed condition after the ropes are pre-stretched, and system behaviour tends to be uncertain if construction stretch is not sufficiently removed.

vii. If fibre ropes are used in conjunction with any wire rope that has a torque response under tension, consideration should be given to the torque generated by the rope and the effect of this torque on the fibre rope. ABS provide guidance on different approaches in relation to the issue [Ref. 1].

viii. When assessing vertical line clearance above infrastructure, consider leeward slack line catenary under maximum conditions for both intact and SLF case.

ix. Mooring swivel type and rig swivel clearance above seabed should also be considered.

x. If there is a difference in load vs excursion between the mooring lines, consider optimising the line pretension with respect to the governing criteria. Purpose of this is to optimise the load sharing between mooring lines.

xi. Care should be taken to ensure that connecting hardware (with exception of ground chain connecting links such as kenter-links or C-links) remains clear of the seabed under all load conditions.

xii. Depending on mooring equipment inspection records (or lack of records) the MBS of mooring equipment may need to be revised. (DNVGL-OS-E301 presents formulas for de-rating mooring equipment).

xiii. Buoys shall be designed according to a recognised standard such as API RP 2SK or OEM's standards.

xiv. Surface buoys shall be designed with a minimum of 25% buoyancy redundancy in all intact conditions. If the buoy is compartmented, flooding of one compartment shall be considered a damage case for analysis.

xv. Clearance of fibre rope from asset/seabed should be checked in event of buoy failure.

5.3 Self-Propelled / Remote Release MODUs

An alternative strategy to managing the risk of moorings failing during cyclone season is to use a Self-propelled MODU with a mooring system which includes a remote release capability (SP/RR MODU).

Where a SP/RR type MODU is used the mooring system does not need to be designed to withstand cyclonic metocean conditions as the MODU's mooring system will not be exposed to cyclonic loads.

However, detailed planning is required to ensure there is sufficient time available for the MODU to respond to potentially cyclonic metocean conditions and depart the drilling location. Following the departure from the drilling location, the MODU's transit speed must be sufficient to allow it to safely manoeuvre away from potentially cyclonic conditions and/or assets.

The Basis of Design Requirements described in Section 5.1 and the Mooring Design Scope of Work described in Section 5.2 are equally applicable when SP/RR MODUs are used, but the planning for the use of an SP/RR type MODU should also consider the following:

i. Risk assessment covering well suspension, disconnection, departure from location, cyclone avoidance and recovery/re-connection of mooring lines.

ii. Computer simulation of mooring line disconnection, followed by sequential mooring line release, should be presented to monitor the effect on MODU station keeping, mooring line recoiling and interaction of lines.

iii. Expected time available from identification of a Tropical Low weather system with potential to develop into a cyclone to arrival of the weather system at the MODU location including any contingency time required by the Titleholder or the MODU Operator.

iv. Response time for MODU to suspend operations on the well and manoeuvre away from the path of the Tropical Low weather system as required by the Titleholder or the MODU Operator.

v. Management of the MODU's VDL to ensure that the MODU can be de-ballasted to a sufficient draft to transit from the field at a speed sufficient to manoeuvre out of the path of the tropical weather system.

vi. Contingency plans in the event that the MODU is unable to manoeuvre away from the Tropical Low weather system.

vii. Qualification testing of Remote Release system and NOPSEMA Scope of Validation requirements for the MODU Safety Case or Safety Case Revision.

viii. MODU specific Remote Release system operating procedures including mooring line tension limits, sequencing of line release and contingency plans in the event that the system does not function as designed.

ix. Training and competency requirements for MODU and/or support vessel crew in the operation of the Remote Release system.

x. Planned Maintenance System (PMS) requirements for the Remote Release system where the MODU is required to remain on location for extended durations without recovering the mooring system, i.e. development drilling campaigns on single drill centre.

5.4 Metocean Return Period Criteria

MODU mooring should be assessed against an appropriate metocean return period. The appropriate return period depends on the level of risk associated with MODU mooring. *Section 3* of this document provides guidance on MODU mooring risk screening which categorises the mooring risk as either Low, Medium or High.

Below table provides guidance on recommended minimum metocean return period based on Table 1 and Table 2 in Section 3.4.

		Consequence Test (Proximity)		
		No	Yes	
Likelihood Test (Season)	Yes	10	20+	10-20
	No	5-10	10-20	10
			Fail	Pass
			Risk Mitigation Test	

Table 3: Minimum recommended metocean RP – Conventional Moored MODUs

Consequence Test (Proximity)		
No	Yes	
5-10	10-20	10
	Fail	Pass
	Risk Mitigation Test	

Table 4: Minimum recommended metocean RP – Self-Propelled / Remote Release MODUs

Notes:

1. The above is guidance only, and higher or lower metocean return periods should be used if deemed appropriate following a documented risk assessment.
2. For mooring scenarios in close proximity to surface or subsea hydrocarbon infrastructure when outside cyclone season, the likelihood of mooring failure may not be as large as when in cyclone

season, but the consequences may be the same or even more severe. For example, the MODU may not be down-manned or evacuated when not in cyclone season. If a mooring failure results in anchors dragging, pipeline damage or MODU drift there are inherent additional risks associated.

3. For cases where Risk Mitigation Tests have demonstrably failed, Return Period should be prescribed based on consequence assessment.

5.5 Risk Based Mitigation Activities

Risk Based Mitigation Activities – Mooring Design & Analysis

Activity No:	Activity Description	Low	Medium	High
5.1	Quasi static mooring analysis.	C	NA	NA
5.2	Frequency domain dynamic mooring analysis.	R	R	HR
5.3	Time domain dynamic mooring analysis.	NA	C	R
5.4	Site specific metocean criteria.	C	R	HR
5.5	Analysis should consider the following sensitivities: Tp variation, allowance for surge and tide.	C	R	HR
5.6	Site specific bathymetry.	R	HR	HR
5.7	Anchor location tolerance checks (installation and drag limits).	C	R	HR
5.8	For single line failure (damaged condition), anchor holding FOS should be reported.	R	HR	HR
5.9	Site specific anchor analysis.	C	R	HR

Note: C – Consider, R – Recommended, HR – Highly Recommended, NA – Not Applicable

6 METOCEAN

This section provides a reference to generic metocean report for the North West Shelf (NWS) as well as a general description of NWS metocean environment.

APPEA commissioned RPS to prepare a guidance document [8] on metocean data which is recommended to be used if site specific metocean data is not available for purpose of MODU mooring analysis. The report presents metocean data tables (Tables 6.1 to 6.16 of the RPS document [Ref. 20]) for four regions of the NWS and provides further detail on the oceanography and meteorology of the area.

The metocean data outlined in the report is generally conservative and may be used for MODU moorings of all risk categories (Low, Medium, High). For medium and high risk MODU moorings, the operator may acquire site specific data to reduce the metocean conditions, as a risk mitigation strategy.

6.1 Salient Oceanographic Features

Prevailing winds in the NWATW are distinctly seasonal, with synoptic winds predominantly from the SW (SSW-W) during the summer (September to March), and from the E (E–SE) during winter (April to August). Transitional seasons (autumn and spring), April and September are brief.

Wind waves (seas) reflect the directionality of the synoptic winds (i.e. SW–WSW in summer and ENE–E and WSW in winter). Swell is perennial and approaches the study region primarily from the WSW.

Tides of the region are semi-diurnal (two highs and two lows per day) with a diurnal inequality (difference in heights of successive highs and successive lows).

Semi-diurnal tidal currents are the most common feature of the local current regime, flowing predominantly across the local bathymetry (roughly E–SE/W–NW) over the continental shelf.

Finally, the region is subject to severe tropical cyclones (in terms of both strength and frequency) in the period between November and April. Tropical cyclones, and their associated wind, wave and current fields represent the most severe environmental conditions across the NWATW.

6.2 Synoptic Meteorology

NWATW meteorological conditions can be separated into two seasons; the winter and summer seasons.

6.3 Winter Season

During winter, April to August, northern Australia, including the North West Australian waters, is dominated by a flow of south-easterly air. For NWATW the winter season is characterised by east south-easterly winds.

6.4 Summer Season

The steadiness of the winter pattern is in marked contrast to the variability of the summer pattern. The summer pattern generates primarily south-westerly winds and with lesser amounts from the west. Tropical cyclones occur from the months of November to April, and cause severe wind, wave and current conditions.

6.5 The Transition Seasons

The periods April and September, are transition months during which either the summer or winter regime may predominate, or conditions may vary between the two. The transition seasons diminish in significance towards northern NWATW.

6.6 Extreme Wind Conditions

Extreme winds can occur throughout the year, easterly gales with wind speeds up to 22 m/s (44 knots) in winter and tropical cyclones with speeds in excess of 50 m/s (100 knots) in summer. At the other end of the spectrum, calms can also occur at any time during the year but are more frequent in summer.

6.7 Easterly Gales (Trade Wind Surge)

Easterly gales (i.e. Trade Wind Surge) occur mostly between May and August as a result of the increase in the atmospheric pressure gradient, which occurs when a strong high pressure cell moves from the Indian Ocean into the western part of the Great Australian Bight. Despite the name, the wind directions may be between south-south-easterly and north-easterly. Wind speeds in the range 12.5 to 20 m/s (25 to 40 knots) may occur twice per winter month.

6.8 Tropical Cyclones

The Australian tropical cyclone season runs from 1 November to 30 April with the majority occurring between January and March. Tropical cyclones usually form in the Timor and Arafura Sea area, and then travel initially in a general south-westerly direction. As the storm develops it can alter its course to travel in a south or south-easterly direction. Further south, tropical cyclone paths become more variable, and storm intensity generally increases reaching a maximum severity at about 20° latitude (i.e. the NWATW study region).

Fully mature tropical cyclones range in size from 100 km in diameter to well over 1500 km. Tropical cyclone size (i.e. diameter) tends to be smaller when nearest to the equator (i.e. within 10°) and larger as the latitude increases.

At maturity, these are the most severe storm type of the area and can produce sustained winds typically in the range 25 to 35 m/s with severe sea conditions, typically 4 to 10 m significant wave height.

During an El Niño event identified by a negative Southern Oscillation Index and lower than average humidity, the average occurrence of tropical cyclones in the tropical cyclone season is reduced. Conversely, during a La Niña which has above average moisture in the atmosphere, storms are more frequent and more intense than in average years.

6.9 Squalls

Squalls with heavy rainfall are associated with thunderstorms occurring at any time of the year. These events can be widespread through the summer tropical cyclone season, especially with an active monsoon. The squalls result from strong downdrafts in the cumulonimbus cloud (i.e. the outflow/air from the thunderstorm downdraft spreads out as the air hits the ground or ocean surface). Winds associated with the squalls may be in excess of 20 m/s for several hours, and in extreme cases may reach 25 to 30 m/s with instantaneous gusts to 45 m/s.

6.10 Wave Climatology

The largest sea states in the NWATW area typically result from locally generated winds. West-southwest swell of low amplitude is a perennial feature. Swell is generated by distant storms, and propagates to the region of interest, slightly diminishing in height due to frictional attenuation while passing over the shallower waters around Barrow Island and Rankin Bank. Swell is largely independent of the local winds. Sea refers to the shorter period waves (i.e. typically < 9 seconds) generated by local winds in the immediate vicinity of a particular site. The sea can be affected by the strength and duration of wind forcing, and by the available distance (fetch) over which the generating wind blows.

The sea state of the NWATW comprises contributions from:

- *Southern Ocean swell:* Southern Ocean Swell is a perennial feature of exposed NWATW. Typically, this swell arrives at the outer edge of the continental shelf from the south and southwest, before refracting during propagation across the shelf, to become more westerly and even north-westerly near-shore.
- *"West Coast" swell:* During summer, strong southerly diurnal coastal winds are a feature of the Western Australian coastline between Perth and the North West Cape. These winds generate sea, and the resulting dispersive swell refracts around the North West Cape and Barrow Island onto the North West Shelf, producing a "burst" of swell passing the area off Dampier, near the edge of the continental shelf, several hours after midnight.
- *Tropical cyclone sea and swell:* Tropical cyclones will generate waves (sea and swell). Depending upon such parameters as storm size, intensity, relative location and forward speed, tropical cyclones may generate sea and swell with periods ranging from 5 to 18 seconds from any direction, with significant wave heights ranging from 1 to 15 m. Typically, most tropical cyclones will generate significant wave heights of 4 to 10 m across the NWATW region. Very intense storms will generate 11 to 16 m significant wave height.
- *Local wind-generated sea:* Local wind-generated sea typically ranges in period from 2 to 7 seconds, but may attain 8 seconds under very persistent forcing. Heights are extremely variable, ranging from 0 to 4 m under non-tropical cyclone forcing. The direction of local sea would be the same as that of the generating wind, unless local bathymetric effects (refraction, diffraction, shielding, etc) act to influence wave direction. In NWATW study area, the seas will be predominantly from the SW–WSW in summer and from the ENE–E and WSW in winter. The most noticeable wind seas causing very rough sea states, on the NWATW are those caused by the winter easterly winds, off the Onslow to Port Hedland coast.

6.11 Current Regime

Principal current driving mechanisms for NWATW are:

1. *Normal (barotropic) tidal currents:* The most observable currents of the area are tidal currents produced by the large rise and fall of the tide (known as barotropic tidal currents). These have peak values of about 0.4 m/s within Mermaid Sound; and increase in magnitude in an offshore direction to the shelf edge, before decreasing in deeper waters.
2. Internal waves (baroclinic tide) and high frequency currents;
3. *Local wind induced currents:* Local wind forcing exerts a shear on the sea surface, which generates waves and transfers horizontal momentum to the water column. The processes of turbulence and mixing subsequently allow for vertical transfer of this horizontal momentum through the water column. Under ambient conditions these currents are typically 0.05 to 0.15 m/s.

6.12 Temperature and Salinity Distributions

Over most of the NWATW, density structure is controlled by the variability of water temperature, because salinity remains relatively uniform.

Surface temperatures and vertical gradients attain their maximum (about 30°C) in late summer. On the outer shelf, the temperatures range down to about 23°C at depths of about 100m. The temperature stratification over the NWATW collapses or becomes isothermal (due to surface cooling and consequent overturning) for one or two months in early winter (water depths to 100m).

6.13 Tidal Range

Tides across the NWATW region are semidiurnal (two highs and two lows each day), with a small diurnal inequality, and a well-developed spring (large) to neap (small) tidal range.

6.14 Risk Based Mitigation Activities

Risk Based Mitigation Activities – Metocean

Activity No:	Activity	Low	Medium	High
6.1	Use generic metocean data (See RPS report [8]).	R	C	C
6.2	Use site specific metocean data.	NA	R	HR
6.3	Use Site specific Tp/Hs contours for wave period sensitivity.	NA	R	HR

Note: C – Consider, R – Recommended, HR – Highly Recommended, NA – Not Applicable

7 GEOTECHNICAL

7.1 Geology of the NWATW of Australia and Geohazards

Below is a brief overview of the geotechnical, geological and geohazard considerations for anchors in NWATW of Australia:

i. Shallow geology is dominated by calcareous soils which differ from soils in other regions by:
   - Being more susceptible to cyclic degradation (cyclic anchor UHC should be taken into account).
   - Often having chain frictions lower than 1.0 (which is referenced in API RP 2SK). Reference [21] provides guidance on the calculation of chain friction factor in calcareous soils.

ii. Cemented calcarenite/limestone units can be found in shallower water:
   - Shallow water depths up to about 120m are likely to have shallow cemented layers and this can be examined through geophysical survey, geotechnical investigation and/or ROV inspection/probing. Isopach maps of depth to cemented calcarenite (or thickness or superficial deposits) may prove useful for risk identification and assessment.
     - If at shallow depth, cemented layers will impede anchor embedment and limit anchor capacity.
     - If at surface, there will be no anchor embedment.

iii. Anchors for cemented calcarenite characteristics:
   - Specialised anchor with proven embedment for hard soils.
   - Heavier or ballasted anchors provide a better chance of penetrating through weakly or variably cemented layers, however these anchors will also require higher tensions to achieve embedment.
   - Site specific anchor capacity assessment is recommended for all areas with potential cemented calcarenite, particularly for MODU moorings in medium and high risk categories.
   - If drag anchors are unable to achieve the required capacities, pile foundations may be used as an alternative. The design and installation of pile anchors generally requires a longer lead time, e.g. 12 to 18 months.

iii. Other geohazards include the following. All geohazards can be summarised in geohazard no-go zone maps:
   - Unstable slopes / scarps should be avoided.
   - The toe of scarps and turbidite channels may contain unpredictable mixed deposits resulting from historical failures and should be avoided.
   - Changes in seabed gradients causing anchor uplift loads should be avoided.
   - Pock marks / shallow gas should be avoided as anchor capacity will be reduced.

7.2 Estimating anchor capacity in calcareous soils

Anchor manufacturers' holding capacity charts are not applicable to calcareous soils and should not be relied upon as they overestimate anchor capacities.

Anchor capacities should be determined through site specific anchor analysis using methods appropriate to calcareous soils and taking into account cyclic loading (detrimental) and consolidation (beneficial). The required inputs for anchor analysis are:

- Geological model and presence of any cemented layers, e.g. from geophysical data.
- Soil strength data, e.g. cone penetration test (CPT), or borehole data.

Anticipated time between anchor installation and loading and the consolidation characteristics of the soil should be considered.

Post-installation anchor drag lengths should be considered and accounted for, i.e. the anchor drag corresponding to maximum anchor holding capacity should be checked in the mooring analysis by reducing the anchor range.

Anchor drag depth should be checked against anticipated geology and the risk of shallow cemented units that will impede anchor embedment and hence limit anchor UHC.

7.3 Sharing Geotechnical Information

There is potential for Titleholders to share:

- Anchor installation and/or test data, e.g. by adding information to a shared or central database.
- Geotechnical information in shared anchoring locations where applicable.
- R&D results through JIPs, university research, conferences and other forums, e.g. Society for Underwater Technology (SUT), Offshore Site Investigation and Geotechnics (OSIG). To be updated if specific JIPs are formed.

7.4 Risk Based Mitigation Activities

Risk Based Mitigation Activities – Geotechnical

Activity No:	Activity Description:	Low	Medium	High
7.1	Cross-tensioning load at winch equivalent to mean line tension for an intact mooring under the maximum design condition.	C	C	R
7.2	Site specific anchor analysis and good understanding of geological model (presence and depth of cemented layers).	C	R	HR
7.3	Anticipated anchor drag checked as anchor range sensitivity in mooring analysis.	C	R	R
7.4	Monitor anchor embedment using transponders fitted to anchors, or ROV if transponders are not available.	C	R	R
7.5	Sensitivity study in mooring analysis for reduced anchor UHC.	C	R	R

Note: C – Consider, R – Recommended, HR – Highly Recommended, NA – Not Applicable

8 MOORING EQUIPMENT DESIGN AND MANUFACTURING

8.1 Scope

This section is intended to provide guidance on the manufacturing and specification of all MODU mooring system equipment normally installed or used on or immediately above the seabed including anchors, mooring chain and accessories including remote release systems, steel wire mooring ropes (including vessel work-wires, tow wires and PCPs), fibre mooring ropes and buoys. This includes both MODU Operator owned and rented equipment.

8.2 Manufacturing, Testing & Certification

Equipment to be manufactured to internationally recognised standards:

Mooring Chain & Accessories (including Remote Release mooring components):	DNVGL-OS-E302 or equivalent
Wire Rope:	DNVGL-OS-E304 or equivalent
Fibre Rope:	DNVGL-OS-E303 or API RP 2SM or equivalent and manufacturer's recommendations
Fibre Rope Damage Assessment:	DNVGL-RP-E304 or equivalent
MODU Anchor Winches	ISO, ABS or DNV GL Class Requirements

Mooring system components shall have full traceability and inspection documentation records in accordance with its certifying body requirements e.g. API or DNV GL.

Mooring equipment must be certified by a Recognised Classification Society (RCS) who is a member of the International Association of Classification Societies (IACS) with rules and standards applicable to MODU design, construction and operation.

Equipment manufacturing, testing & certification records should be available for individual components.

Where mooring equipment traceability records are incomplete, the equipment item should be either replaced or recertified according to the recertification requirements included in the above standards at the earliest opportunity.

8.3 Fibre Rope Mooring Lines

Only fibre ropes specifically designed for offshore mooring systems shall be used:

- Fibre ropes reliant on an external jacket to restrain the individual load bearing sub-ropes should not be used. The rope should be manufactured with a high-efficiency polyester jacket.
- Fibre rope jacket must be permeable to ensure that the rope is free flooded when submerged.
- Fibre ropes must be designed to resist seabed soil ingress and shall be specified with an appropriate filter to exclude soil ingress.

For service conditions where the fibre rope will be exposed to sunlight (i.e. shallow water service and/or outdoor storage), the fibre ropes must be designed to resist high levels of UV radiation and must be manufactured from materials highly resistant degradation from UV radiation.

Fibre ropes should be designed to resist marine growth ingress and be specified with an appropriate filter to prevent marine growth between load bearing fibres.

Where fibre ropes are used as part of MODU mooring system:

- Fibre rope must remain submerged at all times during service to reduce exposure to UV radiation.

- Fibre ropes are very susceptible to damage when in contact with some seabed environments and performance can degrade rapidly. Fibre ropes should remain clear of the seabed during service including during installation and handling, unless the seabed conditions are well understood to allow for temporary grounded during rig move operations.
- Fibre rope has been designed and qualified to prevent the ingress of soils.
- If fibre ropes are used in conjunction with any wire rope that has a torque response under tension, consideration should be given to the torque generated by the rope and the effect of this torque on the fibre rope. ABS provide guidance on different approaches in relation to the issue [Ref. 1].

Fibre ropes should be protected from UV radiation when not in service.

Repairs to load bearing fibre sub-ropes must only be attempted by the rope manufacturer and must be re-certified as per DNVGL-OS-E303 requirements or OEM's procedure.

Field repairs to the non-load bearing outer jacket may be undertaken by competent trained personnel as per DNVGL-RP-E304 requirements or OEM's procedure.

8.4 Remote Release Mooring System

Remote release systems may either be acoustically, mechanically or hydraulically actuated by an ROV. The release system should have a minimum of two (primary and secondary) release mechanisms. The primary and secondary release mechanisms should be independent of each other.

When selecting a remote release system consideration must be given to the operability of the primary and secondary release mechanisms in the field, e.g. acoustic signal transmission from a surface vessel to a selected water depth, ROV operations in areas of high currents, or mechanical release requiring kedging over subsea infrastructure, to ensure that both the primary and secondary release mechanism can be actuated when required.

The functional requirements of a remote release mooring system should consider the following, as a minimum:

- Independent release mechanisms: primary and secondary
- Ultimate loading capacity
- Maximum release load
- Time for release (planned or emergency)
- Tracking mechanism for recovery
- Time for reconnection
- Load monitoring requirement, if any
- Maintenance and inspection.
- Design battery field life

The load bearing components of a remote release system shall be compliant with the same manufacturing, testing and certification requirements as chain accessories as described in Section 8.2. Factory Acceptance Test (FAT) shall be conducted by the manufacturer prior to product delivery to demonstrate that the system can be released and reconnected under the specified functional requirements.

Site Acceptance Test (SAT) should be considered to ensure that the systems will function properly in the field environment.

Remote release equipment shall be compliant with the same storage, maintenance and service history requirements as other mooring components as described below in Sections 9.10 and 9.11.

In addition to the maintenance and service history requirements described in Section 9.11, the remote release system components' Planned Maintenance System (PMS) shall also include the following:

- Maintenance and periodic functional test
- Inspection during retrieval/re-connection

Consideration must be given to the additional components required within each mooring line to facilitate remote disconnection in any pre-cyclone event and subsequent retrieval and reconnection of the mooring system post-cyclone event. Additional equipment is likely to include buoys and pennant wires to allow retrieval of the disconnected mooring lines. The location of any mooring line buoys during disconnection for a cyclone event should be considered to ensure that any risks associated with the subsequent failure/sinking of the buoy or associated equipment during the cyclone event are mitigated appropriately.

8.5 Risk Based Mitigation Activities

Risk Based Mitigation Activities – Mooring Equipment

Activity No:	Activity Description:	Low	Medium	High
8.1	Desktop certification check.	R	HR	HR
8.2	Desktop service history, maintenance, inspection, repair & storage records check.	R	HR	HR
8.3	Independent QAQC verification of equipment condition and OEM certification in compliance with Class requirements.	C	C	R
8.4	Independent review of mooring equipment, component specifications, in-service history and PMS records.	C	R	HR
8.5	Detailed review of mooring equipment handling & installation procedures.	C	R	HR
8.6	Where mooring equipment is not compliant with the manufacturing or testing standards described in *Section 8.2*, gap analysis to be completed and consider replacing items with compliant equipment.	R	R	HR
8.7	Use of good condition pre-lay equipment and/or replacement of MODU equipment with full certification package.	C	C	R
8.8	Use of new pre-lay equipment and/or replacement of MODU equipment with full certification package.	C	C	R
8.9	Destructive testing results or alternative assessment testing to confirm MBS of MODU owned wire rope used in mooring analysis.	C	C	R
8.10	Destructive testing results or alternative assessment testing to confirm MBS of fibre rope used in mooring analysis. Testing of fibre rope yards to get an equivalent MBS of fibre rope can be considered.	C	C	R
8.11	Re-schedule Visual & MPI/NDT PMS equipment inspection and/or maintenance requirements for completion before installing mooring system.	C	R	HR
8.12	Re-inspect mooring equipment before installing mooring system (except where new equipment is being used).	C	R	HR
8.13	Full certification and testing of MODU's mooring system including anchor winches and certification of fairlead sheave and shaft bearings.	C	C	R
8.14	Verification of SP/RR primary and secondary release mechanisms under load through system FAT.	R	HR	NA
8.15	Verification of SP/RR primary and secondary release mechanisms under load through system on-site testing.	C	C	NA

Note: C – Consider, R – Recommended, HR – Highly Recommended, NA – Not Applicable

9 MOORING EQUIPMENT INSPECTION

9.1 Scope

This section is intended to provide guidance on the inspection, maintenance and repair of all MODU mooring system equipment normally installed or used on or immediately above the seabed including: anchors, mooring chain, connectors, swivels, accessories and remote release components, steel wire mooring ropes (including vessel work-wires, PCC and PCP), fibre mooring ropes and buoys.

9.2 Equipment Inspection Standards & Procedures

Mooring equipment shall be inspected to internationally recognised standards and procedures.

Mooring Chain, connectors, swivels & Accessories (including Remote Release mooring components:	DNVGL-OS-E302 or API RP 2I
Wire Rope:	DNVGL-OS-E304 or API RP 2I
Anchor:	DNVGL-OS-E304 or API RP 2I
Fibre Rope:	DNVGL-OS-E303 & E305 or API RP 2I/2SM
Fibre Rope Damage Assessment:	DNVGL-RP-E304 or equivalent

Additionally, the MODU owner will typically specify inspections under a preventative maintenance schedule.

Inspection scopes and resulting reports should include the following:

i. Each item inspected should have a full description, serial number (and any other original OEM marking present), photographic record, manufacturer details, original PO information including OEM and/or Class survey documentation (Certificates) that are available.

ii. Each mooring leg should include a complete description of all components.

iii. Maintenance history of each component against the items documented preventative maintenance schedule.

iv. Inspection history of each component, and the closeout of any recommended actions from these surveys. Note these inspections should include those done by the owner, the OEM, Class or specialist service providers.

v. Inspections of anchors should be to the OEM requirements and should focus not only on structural aspects but also on the condition of items such as keeper plates and fluke angle adjustment pins.

vi. Where applicable the compatibility of items should also be considered (e.g. anchor type and PCC design to ensure compatibility and fit for purpose).

vii. Inspection reports for buoyancy should include quality of welds in/or around the steelworks and padeyes to ensure no degradation due to corrosion or rust.

viii. The results of the inspection should detail gaps against the identified relevant standards and the MODU owner's preventative maintenance system and list actions clearly.

Mooring equipment inspection reports & checklists should be recorded in the PMS and made available to all parties involved in the design, maintenance and operation of the mooring system, (i.e. the MODU Operator, the Titleholder and any Mooring Equipment & Services provider).

Inspection requirements for remote release system are added in Section 9.9.

9.3 Inspector Competence & Training

Personnel involved in the inspection, repair and maintenance of mooring equipment must be competent and hold appropriate certification where applicable. This requirement applies to all mooring operations regardless of risk level.

Organisations providing personnel engaged in the inspection, repair and maintenance of mooring equipment must have a competence management system which specifically addresses the formal and on-the-job or task based training requirements, assessment requirements and certification or qualification requirements for personnel on each specific type of mooring equipment and inspection type.

The organisation’s competency system should be externally audited on a regular basis by an independent auditor.

9.4 Chain, Accessories & Wire Rope Visual Inspection

Visual inspection intervals for mooring equipment should comply with the minimum requirements as per the certifying body e.g. DNV GL or API. An example of inspection interval as taken from API RP 2I is presented in *Table 5* below.

Table 5: Mooring Equipment Inspection Intervals as per API RP 2I

Chain and Accessories		Steel Wire Rope		Fibre Rope
Years in Service	**Inspection Interval**	**Years in Service**	**Inspection Interval**	Fibre rope ICAP must be developed jointly by the owner of the fibre rope, the manufacturer of the fibre rope, the MODU Operator (including the MODU certifying authority) and, where applicable, the Titleholder. Refer to *Section 9.7* (ICAP to be included in the Basis of Design for the mooring system).
0 to 3	36 months	0 to 2	18 months	
4 to 10	24 months	3 to 5	12 months	
Over 10	8 months (Recommended that chain & accessories over 11 yrs old be replaced)	Over 5	9 months (Recommended that wire ropes over 6 yrs old be replaced)	

The history of the mooring component is to be well documented. For steel components, Time-In-Service / Accumulated Service Life (in use) is applicable. If documentation cannot be provided, time counting from original issue date of certificate is to be used. Time-In-Service should include the time the mooring component spent on the MODU or vessel, rigged for operations under load.

For fibre ropes, if the rope is provided by a DNVGL approved rope provider the certificate will be valid independent on certificate date. Otherwise the rope should undergo renewal survey according to certification bodies requirements and no later than every 5 years.

Dry storage times may be omitted from the years-in-service time for a particular item of equipment (wire rope, chains, anchors, links) if inspection details and records of appropriate maintenance can be produced for that equipment. For example, sufficient greasing of wire rope has been undertaken to ensure the wire rope is protected from the elements and corrosion.

Upon receiving spare mooring components from storage (including wet storage), an inspection of the component(s) should be conducted. For equipment following API inspection standard, API RP 2I allows a grace period of four months where the scheduled visual and MPI inspections are expected to fall when the equipment is in service. However, where practical, the inspection should be re-scheduled for completion prior to installing the mooring equipment.

Where a MODU is moored on location for extended durations which prevent implementation of conventional mooring equipment inspection techniques, non-conventional visual inspection techniques for inspecting the mooring equipment in-situ should be considered as an alternative to mitigate the risk of mooring failure, i.e. ROV inspection.

9.5 Chain, Accessories & Wire Rope Magnetic Particle Inspection

It is important to note that the equipment is to be inspected and certified according to its certifying body. This section provides a general guidance on the more commonly used inspection guideline API RP 2I however DNV GL inspection regime is equally appropriate.

API RP 2I provides guidance on the use of MPI techniques on critical equipment items and areas subject to high loads and/or high wear. This typically includes anchor shackles, pear links, swivels, and open links, connecting links, PCP, PCC and wire rope socket eyes. MPI on Quick Release components may be replaced with alternative NDT methods.

The PMS for these components must include MPI inspection regime including critical areas which will be subjected to high wear.

MPI inspection frequency should take into account the equipment service conditions including the high corrosion rates experienced in Australian tropical waters. Inspection interval should be completed on all mooring system components as recommended by the equipment's certifying body e.g. DNV GL or API. An example of inspection interval taken from API RP 2I is presented in *Table 6* below.

Table 6: Recommended Inspection Intervals as per API RP 2I

Years in Service	Inspection Interval
0 to 3	36 months
4 to 10	24 months
Over 10	8 months (Recommended that chain & accessories over 11 yrs old be replaced)

Completing MPI activities in the field is impractical, time-consuming and expensive. Consideration should be given to replacing components requiring MPI at a pre-determined service life. Replaced components may be sent ashore to undergo the necessary inspections.

9.6 Wire Rope Sockets

Consideration should be given to slipping and cutting steel wire mooring lines and re-socketing the wire at regular intervals. The re-socketing interval should be based on historical experience, the condition of the wire socket observed during regular visual inspections and previous service history. In tropical regions, wire ropes are typically re-socketed at service life intervals of 2–3 years.

Wire rope re-socketing must be completed in accordance with requirements set out as per certifying bodies, e.g. API or DNV GL and shall only be completed by trained, experienced and competent personnel. Wire rope sockets shall also come with material certificate.

Where wire ropes are being slipped, cut and re-socketed, a section of wire removed from the mooring line should undergo destructive testing to establish the residual MBS and confirm it is within allowable limits as per API RP 2SK.

9.7 Fibre Rope Inspection

Offshore fibre ropes shall be certified by an IACS member and measures shall be taken to ensure the rope is used within its designated service. A Fibre Rope ICAP (Inspection & Condition Assessment Plan) must be developed jointly by the owner of the fibre rope, the manufacturer of the fibre rope, the MODU Operator (including the MODU certifying authority) and, where applicable, the Permit Titleholder.

The ICAP should be included in the Mooring System Basis of Design as described in *Section 5.1*.

Fibre ropes must be inspected and damage assessed by trained, experienced and competent personnel in accordance with DNVGL-RP-E304 or as per OEM's procedure.

The Fibre Rope ICAPs should, as a minimum, address the following principles:

- Rope design and application
- Storage and condition management
- Installation design considerations
- Spooling, deployment and recovery management
- Records of in-service history/component usage history
- Inspection and planned maintenance system (PMS) requirements
- Damage assessment
- Rope discard, repair and replacement criteria

9.8 Fibre Rope Eye Splice

Re-termination of parallel strand offshore fibre ropes shall be performed by personnel from the OEM or by OEM Approved Service Supplier. The certifying body shall issue a Rope Verification Letter confirming new rope length and that the rope repairs have been conducted by qualified personnel according to approved repair procedure. This letter shall follow the original rope certificate.

Note that by issuing a Rope Verification Letter the certifying body is only addressing the rope repair and not the condition and history for the complete rope. Meaning if the rope needs to undergo renewal survey or similar due to lack of documented history etc., this will still have to be performed as separate activity. Normally a repair to the non-load bearing elements of a fibre rope assembly will not require issuing a new certificate.

9.9 Remote Release System Inspection Requirements

Prior to mobilisation, a campaign specific Planned Maintenance, Inspection and Test Plan (PMITP) should be developed for Remote Release equipment and included in the Mooring BOD.

Remote Release load bearing components must comply with:

- Section 9.2 - Equipment Inspection Standards & Procedures as per Mooring Chain & Accessories requirements
- Section 9.4 - Chain, Accessories & Wire Rope Visual Inspection
- Section 9.5 - Chain, Accessories & Wire Rope Magnetic Particle Inspection

In addition, the PMITP for the Remote Release equipment should address the following:

9.9.1 In-Service Inspection

In-service inspection to be completed when equipment access is possible while operating in the field.

- Visual and dimensional inspection
- Replacement or recharging of batteries
- Re-charging of accumulators (if any)

9.9.2 Scheduled Inspection

Scheduled inspection to be completed at an appropriate repair and maintenance facility when equipment is not in service.

- Visual and dimensional inspection
- NDT inspection (e.g. MPI if applicable)

- Replacement or recharging of batteries
- Re-charging of accumulators (if any)
- Function testing of primary and secondary release mechanisms
- Inspection, testing and replacement of electronic and/or hydraulic components

9.10 Equipment Storage

Equipment storage conditions can have a significant impact on the performance and service life of mooring equipment.

Storage time should be regarded as 'in-service' time unless detailed records of equipment maintenance, inspection and storage conditions are available to demonstrate that the equipment has been properly maintained and stored in compliance with the OEM's recommendations.

Steel wire rope in tropical conditions is susceptible to corrosion and should be stored under cover or suitable protection from the elements.

Fibre rope is susceptible to degradation from UV radiation and should be stored under cover or suitable protection from the elements unless specifically designed for high UV radiation exposure.

Fibre rope is susceptible to degradation from extreme heat and should not be stored in sealed containers unless the containers are kept under cover in a temperature-controlled environment.

9.11 Maintenance & Service History

Maintenance, inspection and repair records for all mooring equipment components should be included in a Planned Maintenance System (PMS) or similar system.

The PMS should include details of storage conditions and durations for all equipment items to ensure that equipment inspections based on 'service years' are scheduled appropriately.

Equipment maintenance and service history records must be traceable to origin and available for individual components. Alternatively, a renewal survey with scope specified by the certifying body shall be performed if equipment history is lacking. A detailed renewal survey specified and followed up by the certifying body should reveal the condition and if any damages to the equipment.

The PMS system should be capable of maintaining the traceability, service history and storage conditions of mooring equipment items such as connector links, PCPs which are frequently removed and/or replaced.

9.12 Pre & Post Tropical Cyclone Inspection Requirements

Cyclone season preparation and mooring inspection activities should, as a minimum, comply with the guidance provided by its certifying body, e.g. DNV GL or API RP 2I Annex B.

Where a MODU's mooring system has been subjected to cyclonic metocean conditions resulting in a failure of a mooring system component, any subsequent mooring equipment inspection, repair, load testing and return to service should, as a minimum, comply with the guidance provided by API RP 2I Annex B.

Where a MODU is moored on location for extended durations which prevent implementation of conventional mooring equipment inspection techniques and the mooring system has been subjected to cyclonic metocean conditions, non-conventional visual inspection techniques for inspecting the mooring equipment in-situ may be considered post-cyclone event, i.e. risk based ROV inspection techniques.

9.13 Risk Based Mitigation Activities

Risk Based Mitigation Activities – Mooring Inspection

Activity No:	Activity Description:	Low	Medium	High
9.1	Desktop certification check.	R	HR	HR
9.2	Check mooring equipment current within MODU or equipment supplier PMS.	R	HR	HR
9.3	Independent audit of equipment supplier and MODU PMS to confirm inspection & maintenance requirements are completed as required.	C	R	HR
9.4	Independent QAQC verification of equipment by qualified marine engineering/naval architect.	C	C	R
9.5	Review and, where required, re-complete Visual Inspection PMs prior to commencing operations with specialist mooring contractor.	C	R	HR
9.6	Review and, where required, re-complete MPI/NDT inspection PMs prior to commencing operations with specialist mooring contractor.	C	R	HR
9.7	Re-socket MODU owned steel wire rope sockets prior to commencing operations with specialist mooring contractor.	C	C	R
9.8	Destructive testing of MODU owned steel wire rope to confirm MBS.	C	C	R
9.9	Visual inspection of mooring lines post-cyclone (where mooring system remained intact).	NA	C	C
9.10	MPI of mooring lines post-cyclone (where mooring system remained intact).	NA	C	C
9.11	ROV in-situ visual inspection of mooring lines post-cyclone (where mooring system remained intact).	C	R	HR
9.12	ROV in-situ visual mooring line inspection programme where MODU is moored for extended durations (i.e. multiple well development drilling on a single drill centre) and conventional visual/MPI inspections are not practical.	C	R	HR
9.13	ROV in-situ visual inspection of mooring lines post-installation.	R	R	HR
9.14	Audit of specialist mooring contractor's competence system and training records.	C	C	R
9.15	Full certification and testing of MODU's mooring system including anchor winches & fairleads.	C	C	C
9.16	Function test Remote Release primary and secondary release mechanisms under load prior to deployment	C	C	N/A

Note: C – Consider, R – Recommended, HR – Highly Recommended, NA – Not Applicable

10 MOORING OPERATIONS

10.1 Scope

This section is intended to provide guidance on the marine operations involving MODU mooring systems including prelaid equipment using wire or fibre rope mooring lines and disconnection/reconnection of remote release mooring systems. Planning of MODU mooring operations should consider:

- Compliance with Local, Governmental and Class Guidelines, Recommended Practices and legal requirements. (e.g. NOPSEMA / APPEA / DNV GL/ GOMO)
- Operational standards & procedures
- MODU, Mooring Contractor and Vessel crew competency and training
- Mooring design, rigging and handling
- Mooring installation and recovery procedures
- Marine operations
- Tropical Cyclone Preparation and Response philosophy (e.g. down-manning, SP/RR MODU to depart location)

10.2 Standards & Procedures

Mooring operations shall be conducted according to internationally recognised standards & procedures. The following are endorsed:

Vessels: Guidelines for Offshore Marine Operations (GOMO)

Competence: DNVGL-ST-0027:2014-04

10.3 Vessel and MODU Personnel Competence & Training

Personnel involved in the installation of mooring equipment shall be competent in accordance with DNVGL-ST-0027:2014-04.

Organisations providing personnel engaged in the installation and operation of mooring equipment shall have a competence management system which specifically addresses the formal and on-the-job or task-based training requirements, assessment requirements and certification or qualification requirements for personnel on each specific type of mooring equipment.

Vessel & MODU Operator's competence management systems should be capable of recording their field personnel's experience with mooring installation and retrieval operations.

The organisations competency system should be externally audited on a regular basis by an independent auditor.

10.4 Mooring System Rigging and Handling

To avoid unnecessary damage and ensure asset integrity, consideration must be given to MODU mooring operations and a detailed design review should consider as a minimum:

- Component placement within conventional / prelaid / remote release mooring line configurations.
- Lashing / rigging methodology used to secure devices external to any in-line components (clamps, flotation devices, riser arrangements etc).
- Safe handling / recommended practices to avoid fatigue and maintain equipment integrity.
- Acoustic release activation and reconnection requirements.

10.5 Mooring Operations Procedures

Planning for the mooring operation shall be carried out in advance to allow for sufficient time for design and analysis of the mooring system as described in this document. This includes the appropriate amount of time to complete the required inspections and maintenance that must be completed prior to the mooring operation.

The MODU Operator shall prepare installation procedures for the mooring system as described in GOMO. Where components of the mooring system are not owned by the MODU Operator, the preparation of procedures may be outsourced to a specialist marine contractor.

Pre-rig move checklists should be provided to assist MODU and vessel crews in preparing the MODU moves, mooring installation and retrieval operations.

The mooring installation and recovery procedures shall be reviewed by all parties involved in the design, installation and retrieval of the mooring system including MODU Operator, Titleholder, Vessel Operator and any specialist contractors providing mooring equipment or services. Regardless of the ownership of individual equipment items or preparation of installation and retrieval procedures, the approval of these procedures lies exclusively with the MODU Operator.

Anchor handling and transfer operations shall not take place above subsea equipment and pipelines. If an anchor handling vessel is required to transit over subsea infrastructure while installing a mooring line the anchor must be decked and secured prior to transiting over the infrastructure.

The mooring installation and recovery procedures shall include reference to appropriate 'safe handling' locations with sufficient horizontal clearance from subsea infrastructure for heavy lift operations such as subsea BOP and anchor handling.

The mooring installation and recovery procedures shall include reference to an appropriate 'survival' location where the MODU will be positioned during extreme weather events. The mooring system should be designed such that mooring line load distributions are symmetrical at this location to minimise the risk of an individual mooring line failure during a severe weather event.

Where practical, the survival location shall be located clear of any subsea infrastructure to minimise the risk of dropped objects from the MODU impacting on subsea infrastructure during severe weather events.

The mooring installation and recovery procedures shall address how minimum horizontal and vertical clearance requirement from subsea infrastructures are to be maintained. If mooring lines need to be pre-laid on the seabed, they must comply with clearance requirement outlined in the standards.

The mooring installation and recovery procedures shall include minimum required line tensions to ensure mooring system components such as fibre rope to remain clear of the seabed including during kedging to safe handling and survival locations. The minimum line tensions must account for the slacking off of line tensions at the survival location during severe weather events to ensure that chain/rope connectors remain clear of the seabed in the slacked off condition. Leeward slack lines during severe weather events should also be considered.

During rig move operations, there may be a requirement for mooring system components such as wire rope, fibre rope and chain/rope connectors etc to contact the seabed. Any requirement for mooring system components to contact the seabed other than those components specifically designed for this purpose, i.e. mooring chain etc, should be considered in the mooring system BOD.

Where a suitable vessel equipped with an ROV is available, consideration should be given to ROV visual inspections of the touchdown points, fibre rope and any jewellery and subsurface buoys in the mooring line.

For close-proximity mooring in cyclone season, it is recommended that a competent and established third party marine surveyor or mooring engineer be on-board the MODU to oversee the installation/disconnection of the mooring system and verify that the mooring system is installed according to the mooring design and analysis.

Where mooring equipment is being installed or retrieved in close proximity to subsea infrastructure, consideration should be given to the use of real time 3D visualisation survey systems to assist in the position monitoring and placement of mooring equipment.

Where mooring equipment is planned to be decked on the vessel for any reason, consideration should be given to having competent specialist mooring contractor personnel on board the vessel to assist vessel crews with the handling of mooring equipment.

All mooring lines should have detailed mooring line configuration drawings prepared prior to installation or retrieval describing each component. Images of each component should be included to aid vessel crew in the identification of all components where mooring line jewellery is assembled on a vessel.

Mooring line configuration drawings shall be approved by the MODU Operator, Titleholder and Specialist Mooring Contractor prior to installation. Any changes to the approved mooring line configuration should be approved via the MOC process.

The planned cross tensioning requirements should be outlined and form part of the final acceptance of the mooring system once it is installed. Refer to *Section 10.6* for further details on what should be considered for this section of the installation procedure(s).

A Management of Change (MOC) process shall be implemented for any material changes required to the approved mooring installation and recovery procedures. Any changes to procedures should be reviewed, endorsed and approved by the same parties that are involved in the original procedures review process.

10.6 Anchor Installation Requirements

Mooring lines should be proof-load tested after installation. Proof-loading can be achieved using AHV during prelay (if applicable) and/or by cross-tensioning using MODU winches. The purpose of proof-loading the mooring lines and anchors is to:

- achieve adequate anchor embedment, in case of drag/plate anchors;
- eliminate slack in the ground chain and develop inverse catenary;
- prove installation holding capacity, noting that anchor capacity may be lower in a storm due to cyclic degradation of the soil;
- reduce anchor drag distances during storm loading;
- proof-load other components of the mooring system (during cross-tensioning with rig winches).

As per API RP 2SK, for mobile moorings with drag anchors, the test load should be determined by type of anchors, soil condition, winch pull limit and anchor retrieval.

Section 7.4.3 of API RP 2SK gives following minimum requirements for mobile MODU mooring proof-load:

- Test load at the anchor shank should not be less than 3 times the anchor weight.
- The mooring test load at the winch should not be less than the mean line tension for an intact mooring under the maximum design condition. (Note, API RP 2SK states that this requirement is for “close proximity moorings”. See *Section A1* for definition).
- Duration of the test load should be at least 15 minutes for each line with no detectable anchor drag.

Anchors may be fitted with transponders to provide additional information on anchor embedment and orientation. ROVs may be used as a visual check on anchor embedment during and/or post-installation.

10.6.1 Contingencies

In the event that the mooring test load is not achieved, the following contingencies may be considered subject to compliance of design criteria:

- Increase the consolidation time (soaking anchors) to increase holding capacity, however this will be subject to soil characteristics.
- Increase anchor range or add more ground chain to reduce proof load at the anchor. However unrealistic line length to meet criteria shall not be used in the analysis [Ref. 5].
- Use ballasted anchors to achieve greater embedment.
- Use larger anchors to improve holding capacity.

10.6.2 Design Tolerance

At the completion of the installation operations, checks should be carried out to ensure the as-laid mooring system has been installed as per approved procedure. This is to ensure the installed mooring system complies with design standard and to ensure operability of the mooring system (e.g. kedging and remote release as per design).

One of the checks is to ensure the as-laid anchor positions are within the anchor drag tolerance box specified in the Mooring Analysis and Scope of Work. In the event that anchors are not positioned within the required tolerance, mooring design calculations should be re-done using as-built anchor positions to confirm that the mooring design still meets design requirements.

The rig component payout should also match the mooring analysis to ensure the MODU can kedge and skid during operations as per design.

10.7 Remote Release System

10.7.1 Installation of Remote Release System

During installation of the remote release unit, proper inspection will need to be carried out prior to deploying the system. The type of inspections have been discussed and presented in Section 9.9.1 and Section 9.9.2. The unit can either be buoyed-off as part of the prelaid lines or inserted during the rig move operations. Proper assessment shall be carried out to determine the best option with ALARP risk.

10.7.2 Operation of Remote Release System

In general, there are two types of field operation of a remote release mooring system: planned release or emergency release. For each type, detailed operation procedure should be supported by numerical modelling and reviewed prior to the field deployment. Computer simulation of mooring line disconnection, followed by sequential mooring line release, should be considered

to monitor the effect on MODU station keeping, mooring line recoiling and interaction of lines.

Remote release systems are typically positioned close to the MODU in order to facilitate access for primary or secondary release and retrieval/re-connection are therefore subjected to high mooring line tensions. The mooring system specifications must consider the location of the remote release system components and loads that these components will experience while in service including during installation, retrieval, kedging, release & retrieval/re-connection and the location of the release system components.

In addition, the analysis of the release operation, as part of the field procedure development, shall simulate the mooring line fall path after the release. The sequential trajectories of the falling line and the final location on the seabed shall be checked to maintain the minimum clearance requirements from the remaining connected mooring lines and any subsea infrastructure. Any risks, such as overloading the remaining mooring lines, anchor drag and collision into other surface structure in the proximity, shall be evaluated and mitigated.

10.8 Tropical Cyclone Preparation & Response

10.8.1 Conventional Moored MODU

MODU specific tropical cyclone response procedures must be developed and reviewed prior to each cyclone season. Checklists should be provided to assist MODU crews in preparing the MODU for de-manning. An example Cyclone Preparation Checklist is provided in *Appendix B*.

MODU Operators shall ensure that procedures for slacking off mooring lines to storm tension are done in accordance with the location specific mooring analysis. Storm tensions must ensure that chain/wire crossovers retain adequate clearance from the seabed under cyclonic conditions to reduce the risk of equipment failure.

MODU should be kedged to the mooring centre, or alternative location where the performance of the mooring system is optimal and overall mooring risk is minimised.

Where MODUs are operating in areas close to manned facilities, consideration should be given to holding joint facility exercises for a scenario where a MODU is adrift. This may need to include other Titleholders where their facilities are in the vicinity of the MODU.

Contingency plans should be developed in the event of a MODU mooring system failure, including during cyclones where the MODU has been de-manned. An example of a MODU Mooring Failure flow chart is provided in *Appendix C*.

Where MODU is operating in areas close to manned facilities, consideration should be given to installing a pre-rigged emergency tow bridle on the MODU to allow an emergency tow line to be established without having to board the MODU and potentially expose personnel the HSE risks associated with a collision.

Consideration should be given to installing a Position Indicating Transponder with an independent power supply to ensure that any MODU loss of station-keeping or mooring failure event to be identified as soon as possible.

Consideration should be given to installing winch tension data recorders with an independent power supply to allow the recording of actual mooring loads experienced by the MODU to provide data on actual loads experienced during the cyclone event and identify whether mooring equipment has been over-loaded while the MODU is de-manned.

10.8.2 SP/RR MODU

The following will need to be considered on a SP/RR MODU for cyclone preparation and responses:

- T-time calculation for cyclone response.
- minimising VDL where possible during cyclone season.
- If required, include allowance for de-ballasting to draft required for MODU to transit at sufficient speed to manoeuvre away from cyclone activity.
- Allow sufficient contingency to activate secondary or tertiary release (if available).
- Consider down-manning personnel in to minimise HSE risk exposure

10.9 Risk Based Mitigation Activities

Risk Based Mitigation Activities – Mooring Operations

Activity No:	Activity Description:	Low	Medium	High
10.1	Consider installation of a Position Indicating Transponder with independent power supply.	C	R	HR
10.2	Identify 'safe handling' location for heavy lifts including BOPs.	R	HR	HR
10.3	Identify 'survival' location for cyclone de-manning over subsea infrastructure with symmetric loading of mooring lines.	NA	R	R
10.4	Confirm minimum mooring line tensions required during cyclone activity, ensure these are understood by MODU marine personnel and are included in the Cyclone Response Checklist.	NA	HR	HR
10.5	Develop MODU specific Cyclone Response Checklists for preparing for cyclone activity and de-manning the MODU.	NA	HR	HR
10.6	Develop Cyclone Response Checklists for facilities in Close Proximity to the MODU and potentially de-manning and/or suspending production.	NA	R	HR
10.7	Develop contingency plans for MODU mooring system failure including during cyclone events with the MODU de-manned.	C	R	HR
10.8	Develop contingency plans for facilities in Close Proximity to the MODU in the event of a MODU mooring system failure including during cyclone events with the MODU de-manned.	NA	R	HR
10.9	Deploy mooring equipment specialists onto anchor handling vessels during mooring installation & retrieval to minimise the risk of equipment damage to incorrect handling practices.	C	R	HR
10.10	Audit of specialist marine equipment contractor's competence system and training records.	C	C	R
10.11	Deploy marine surveyor or mooring engineer in field to oversee the installation/disconnection of the mooring system and verify that the mooring system is installed according to the mooring design and analysis.	C	R	HR
10.12	Use real time 3D visualisation survey systems to assist in the position monitoring and placement of mooring equipment.	C	R	R
10.13	Install Emergency Tow Bridle on MODU to allow tow line to be established without boarding drifting unmanned MODU.	NA	C	C
10.14	Hold Emergency Response exercise with a drifting unmanned MODU scenario including Titleholders operating production facilities in close proximity to the MODU location.	NA	C	C
10.15	Re-schedule MODU operations outside of cyclone season.	NA	C	C
10.16	Conduct ROV inspection after hook-up and cross-tensioning to verify and validate the integrity of the mooring system.	C	C	R
10.17	Perform a Site Acceptance Test (SAT) of a remote release mooring system right after the field deployment	R	HR	HR
10.18	Precautionary down-manning of non-essential personnel for SP/RR MODU.	R	HR	NA
10.19	Contingency plan for connecting AHV to tow bridle in the event that MODU departs location later than T-time to increase transit speed.	R	HR	NA

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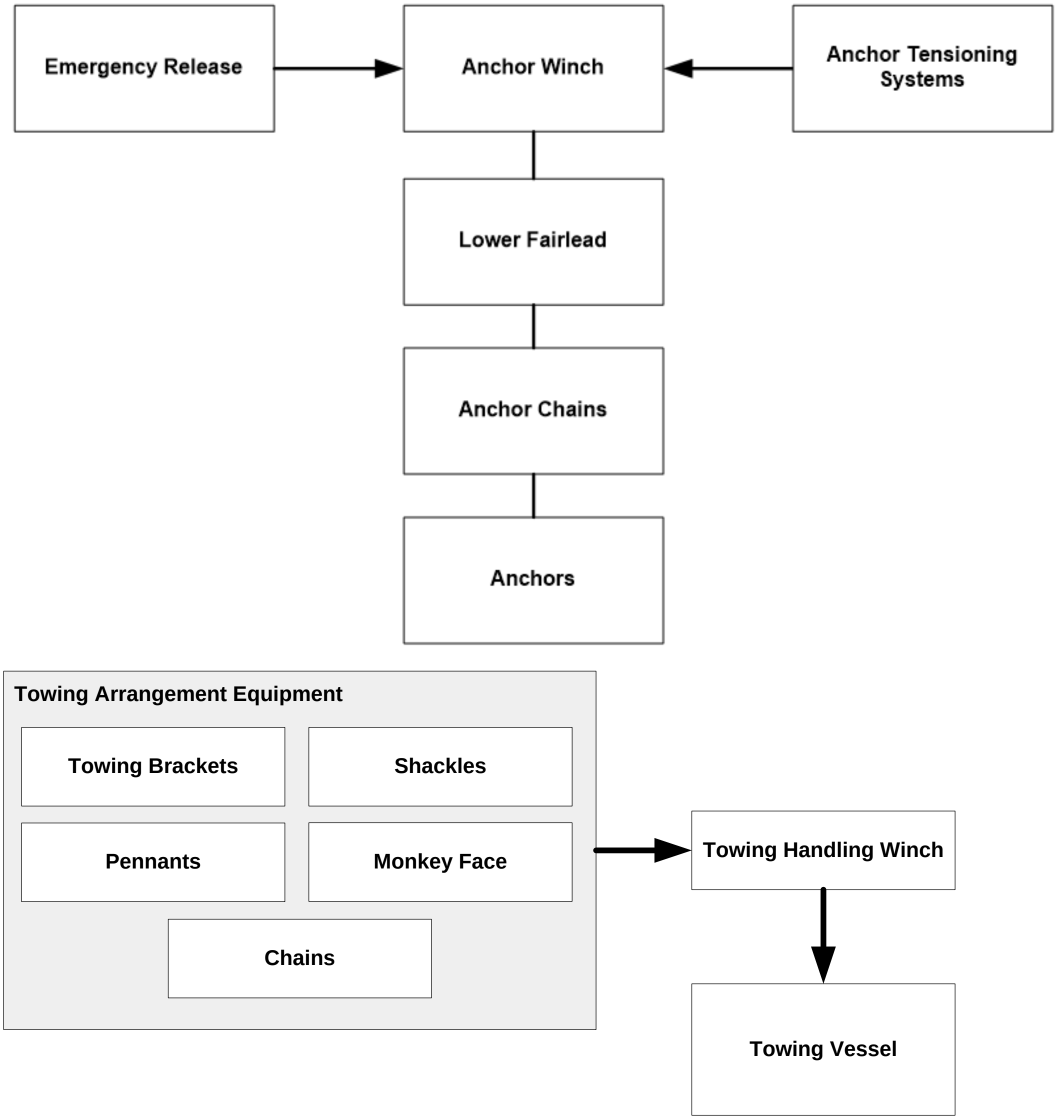
21. Stanier et al. A tool for ROV-based seabed friction measurement, 2014, URL https://kundoc.com/pdf-a-tool-for-rov-based-seabed-friction-measurement-.html)

APPENDIX A: MODU MOORING SYSTEM PERFORMANCE STANDARD

PERFORMANCE STANDARD: SCE-06 POSITIONING/TOWING SYSTEMS	*Performance Objective: To maintain the rig on station in any design conditions, and to restrain it within any excursion limits necessary for operations.*

SYSTEM OVERVIEW

The Rig Positioning/ Towing Systems (SCE-06) are involved in the station keeping of the rig during operations and in survival mode. The system also includes towing equipment which enables tugs to safely tow the rig onto and off location. The following figure presents a plan view of a mooring system windlass on the rig's starboard forward corner.



FUNCTIONALITY

Performance Criteria	Basis	Performance Verification – Assurance Tasks
FUNCTION 1: To enable the vessel to maintain position and orientation within the mooring operating envelope.		
1. To provide anchor structure and attachments of sufficient strength to withstand the maximum loading.	DNV Rules OS-E301 Section 4 89 MODU Code Chapter 2	Anchor chain visual inspection for defects (Proc. DDxxxxx) Anchor winch tension system inspection, maintenance and operation testing (Proc. DDxxxx)

	API - RP 2SK - Design and Analysis of Station keeping Systems for Floating Structures - 3rd edition 2005 API RP 2I -In-Service Inspection of Mooring Hardware for Floating Drilling Units	Anchor examination for damage during rig move (Proc. DDxxxxxx) Anchor inspection and repair (Proc. DDxxxx)
2. To provide location specific assurance mooring integrity	API 53 API RP 16Q API - RP 2SK - Design and Analysis of Station keeping Systems for Floating Structures - 3rd edition 2005	Mooring analysis and riser analysis, along with location approval is used to complete the risk assessment (Proc xxx) Location approval conducted by independent third party (Proc XXX)
3. To provide flexible mooring lines with a safe working load at least equal to the maximum calculated loading in all design weather conditions.	UK HSE Fourth Edition Guidance DNV Rules OS-E301 Section 4	Anchor chain physical testing and inspection of joining links (Proc. DDxxxxx) Inspection and calibration of anchor chain tension chart recorder (Proc. DDxxxx)
4. To provide windlasses capable of imposing tension in the mooring system up to the maximum design tensions for adverse weather	UK HSE Fourth Edition Guidance DNV Rules OS-E301 Section 4	Windlass inspection and maintenance (Proc. DD xxxxx) Brake inspection and operation check (Proc. DDxxx)
FUNCTION 2: To provide a chain release facility for moving the rig off station in an emergency.		
1. To allow the facility to move off station by facilitating emergency chain release, and the catenary action of the upwind chains hauls the installation off station.	Safety Case 89 MODU Code Chapter 4	Windlass inspection and maintenance and operation check (Proc. DDxxxx) Function test emergency release from Local Winch House and ECC. (Proc. DDxxxx). Visual inspection of Anchor Winch Hydraulic Power Packs and verification of pressure. (Proc. ME xxxx)
2. To minimise the risk of sparking and friction during chain release, by use of deluge.	Safety Case	Functional test of deluge system fitted to each of the windlasses automatically functions during remote emergency release test after ESD 2 activation. (Proc. CLxxxx)
FUNCTION 3: To provide a link between the towing vessel and the drilling rig during a move and emergency scenarios.		
1. Towing arrangements to be provided for rig move operations utilizing one or two support vessels.	DNV Rules OS-E301 Section 4 89 MODU Code Chapter 14	Inspection of towing equipment prior to every rig move operation. (Proc. DDxxxx) Towing lugs survey. (Proc. DDxxxxxx) Equipment replacement Inspection of towing arrangement retrieval winch. (Proc. DDxxxx)
AVAILABILITY/RELIABILITY		
SCE Ref. **System / Subsystem**	**Basis**	**Performance Criteria**

SCE-06	Positioning/ Towing Systems		The rig will not operate (When latching or drilling though the BOP) with less than full deployment and serviceability of mooring system. Availability is confirmed at each location, and safety factors are used in choice of chain. (xxxxxxxxx Marine Operations Manual, Rig Moving and Towing Operations)

SURVIVABILITY				
Ref.	**MAH**	**Subsystem**	**Basis**	**Performance Criteria**
27.1.1	Rig Founders/ Capsizes – Severe Weather	Positioning System	Safety Case	Failure of single chain will not cause progressive failure of other anchor chains.
				Unit is classed for worldwide operation at prescribed water depths.
ALL BO	Blowout (BO) on Rig Blowout Subsea	Positioning System	Safety Case	Downwind chains will be released (manually or in emergency release) to prevent the unit moving down wind of hazard.

INTERACTIONS/DEPENDENCIES		
Ref.	**System / Subsystem**	**Justification**
SCE 12	Deluge System	Sparks are generated on sudden releases (such as Emergency release)
SCE-07	Collision Avoidance	To facilitate safe manoeuvres during orientation of vessel and provide audible and visual warnings to vessels/installations in close proximity during such manoeuvres.
SCE-22	Stand-by Vessel	Normally the Anchor Handling Tug can help with chain and Anchors.
SCE-28	Main Power Generation	Main power is required to haul in anchor chain/provide power during controlled move off.
SCE-29	Emergency Power	Provides power to anchor winch hydraulic power packs for emergency release
SCE-30	UPS	Provides back-up power supply to emergency release solenoids
SCE-35	Temporary Equipment	Third party mooring equipment attached to rig's mooring system

Deviation Guidance – Effecting Operating Envelope	**Action**	**Case for Safety**	**Regulator Communication**
Loss of one anchor	NCR, risk assessment and if drilling through the BOP pull back to surface and stop drilling until full deployment.	Yes	N
Loss of two anchors	Emergency disconnect	Shutdown	Y
Loss of Tension measuring system	NCR, risk assessment, regular manual checks with motor amps against pull, monitoring of BOP location (subsea beacon).	Yes	N

ALARP STATEMENT
With the Performance Criteria maintained to the agreed basis the SCE is considered to demonstrate an ALARP control.

APPENDIX B: MODU CYCLONE PREPARATION CHECKLIST

DISTRIBUTION LIST	Rig Manger Client Logistics Attending Supply Vessels Helicopter Operator
DATE	
PAGES	

Rig Name	
IMO NUMBER	
MMSI	
OFFICIAL NUMBER	

TOTAL FUEL	
TOTAL POT WATER	
TOTAL POB	

SAFE AREA POSITION	Lat	Long	Rig Heading
RIG DRAFT			
Anchor #1	Tension		Length
Anchor #2	Tension		Length
Anchor #3	Tension		Length
Anchor #4	Tension		Length
Anchor #5	Tension		Length
Anchor #6	Tension		Length
Anchor #8	Tension		Length
Anchor #9	Tension		Length
Anchor #10	Tension		Length
Anchor #11	Tension		Length

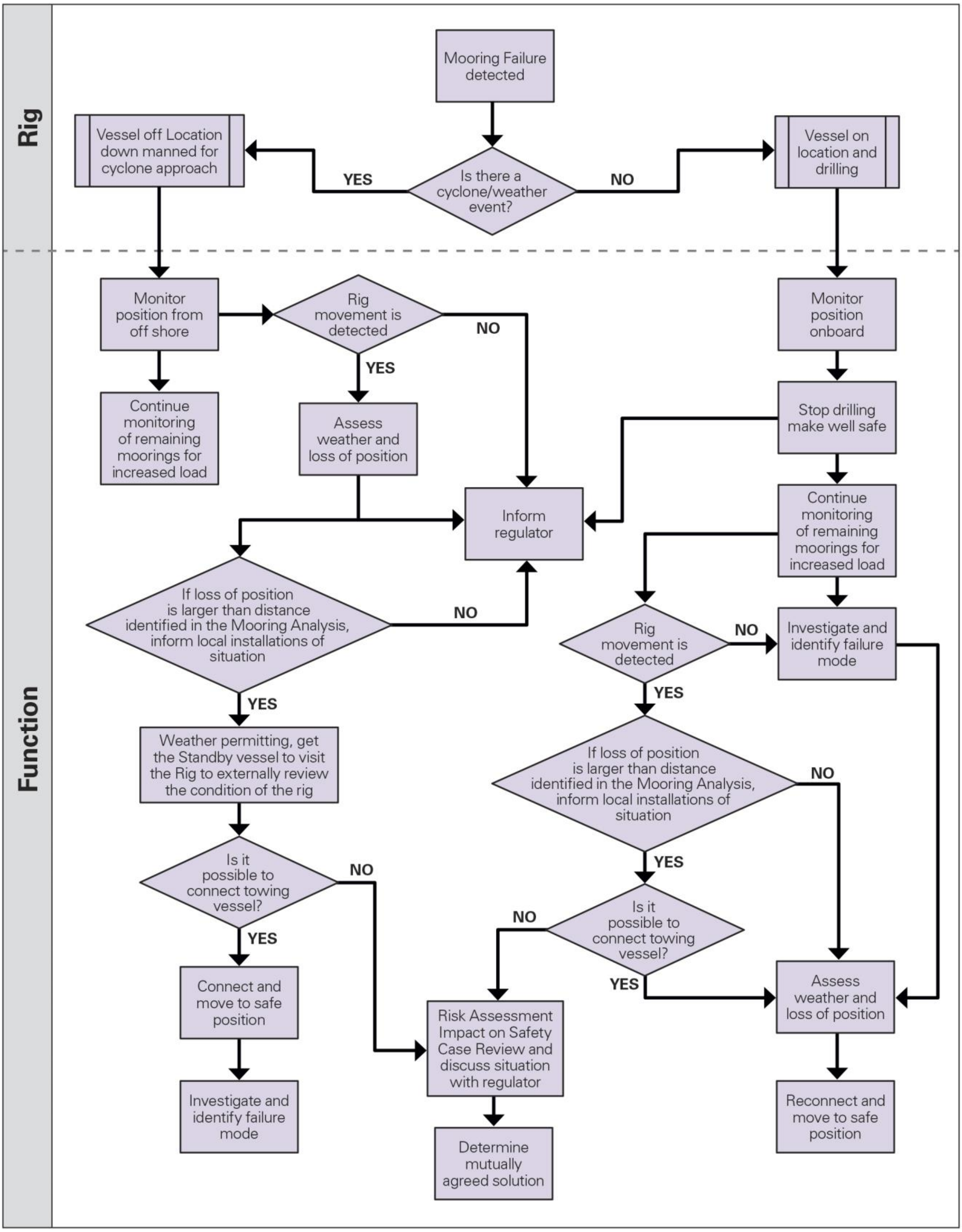
Anchor #12	Tension	Length
DEPARTURE ETA LAST HELICOPTER		

CONFIRM TRACKING SYTEM OPERATIONAL AND WORKING WITH RIG MANAGER ASHORE	Tested and Date
BACK UPPOWER FULL CHARGES FOR TACKING SYSTEM	Power level
CONFIRM RECOVERY PLAN FOR TOWING BRIDLE WITH ATTENDING SUPPLY VESSEL.	

INFORM OPERATORS WITIN 10 nm WITH SURFACE FACILITIES AND SUB SEA PIPELINS OF THE RIGS POSITION	
AGREE ON MONITORING AND REPORTING TRIGGERS WITH CLIENT	

VESSELS IN ATTENDANCE	

APPENDIX C: MODU MOORING FAILURE FLOW CHART



APPENDIX D: EXAMPLE MOORING BASIS OF DESIGN FORM

MOORING ANALYSIS
BASIS OF DESIGN FORM

Well Name:		**Drilling Contact:**	
Rig Name:		**Mooring Contact:**	
SCOPE OF WORK:		**Date:**	

Sample Text:
Perform an frequency domain dynamic mooring analysis and mooring pattern design, for Well-1 drill centre for full cyclone season
- Use Joint Maxima metocean data
- Consider conventional rig system. If conventional rig system fails, consider fibre prelay system
Perform quantitative risk assessment taking into consideration surrounding subsea and surface infrastructure.

Mooring analysis report is to include the following sensitivity studies for the governing loadcase:
- Time period sensitivity using referenced Tp/Hs contours
- Anchor location sensitivity to account for installation tolerance and anchor drag during cross-tensioning

Assume drag coefficient of 1.8 for wire and 2.6 for studlink chain as per DNV-RP-C205
Note that the presence of subsea infrastructure as per referenced drawing files

DESIGN CRITERIA:	
Mooring Analysis & Design Standard	API
Exclusion Zones & Clearances to Infrastructure	As per API
Offset criteria	As per API
Dynamic or Quasi-Static Analysis	Dynamic
Analysis Type	Frequency Domain
6 or 3 degrees of freedom	6 Degrees

EQUIPMENT & INSPECTION:	
Rig technical specifications	winch specs, relevant (rig) schematics, RAO's, hydro dynamic co-efficients etc.
Mooring Equipment	rig mooring equipment or third party supply, is new equipment required etc.?
Equipment inspection requirements	Is there any special inspection or testing being planned i.e. wire specimans
Third Party assurance	Will there be any specific 3rd party inspection or verification i.e. DNV

GEOSPATIAL:

Datum	GDA94	Projection (Zone)	
Drill Centre Co-ordinates	Easting (m)		Northing (m)
	LAT Water Depth		Nominal MODU Heading

<u>Provided Data</u>

Subsea infrastructure Layout	*Reference Drawing/Map*
Bathymetry	*Reference Drawing/Map*

METOCEAN:

<u>Provided Data</u>

Metocean Data Report/Tables	*Metocean Data Reference*
Storm Surge (m)	
Max Tide (m)	

GEOTECHNICAL

<u>Provided Data</u>

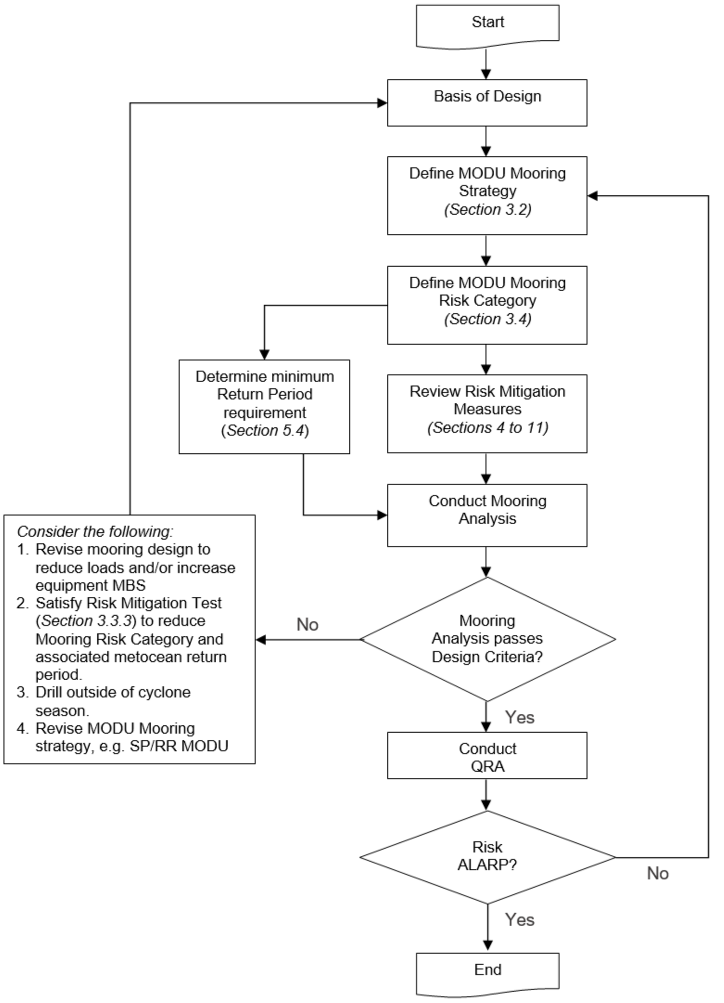
Site Specific Geotechnical Report		*Add Document Reference*
Anchor analysis		*Add Document Reference*
Geohazard analysis		*Add Document Reference*
Chain friction factor	1.0	*Add Document Reference*

SIGN-OFF

Compiled by	*Reviewed by*	*Reviewed by*	*Concurrence*
Project Engineer	**Metocean Authority**	**Geotechnical Authority**	**Drilling and Completions**
Name:	*Name:*	*Name:*	*Name:*
Signature:	*Signature:*	*Signature:*	*Signature:*
Date:	*Date:*	*Date:*	*Date:*

APPENDIX E: MODU MOORING WORKFLOW GUIDANCE

The below aims to break down the MODU mooring workflow provided in *Section 2.1* and offer guidance on each step. The workflow is broken down into five steps as shown below:



Step 1 – Basis of Design

Step 2 – Define MODU mooring strategy during cyclone season

Step 3 – Define MODU mooring risk category

Step 4 – Review risk mitigation measures and determine minimum metocean return period

Step 5 – Conduct Mooring Analysis

Step 6 – Conduct Mooring Risk Assessment

Step 1 – Basis of Design

Collection of relevant and reliable MODU mooring information is critical to achieving a high level of certainty in the final MODU mooring design. The lists below describe the relevant information for the mooring site and the MODU vessel which will form the mooring BOD.

Metocean:

Is site specific metocean data available? If not, generic NWATW metocean data can be used which can be extracted from RPS report [20]. The data outlined in the aforementioned report is considered to be conservative. Therefore obtaining site specific data may improve the results of the mooring analysis.

If obtaining site specific data, consideration should be given to the scope of the data which is to be supplied. It may be beneficial to include joint maxima data, rather than independent extremes. This will also remove some of the conservatism and improve results of mooring analysis.

See Section 6 for more information.

Geotechnical:

Have soil samples been taken at and around the proposed drill centre? If so, is there a geotechnical report available? Does the site have any shallow cemented calcarenite layers?

The purpose of the anchor analysis is to:

- Determine the optimal anchor fluke angle
- Predict anchor drag and embedment under load
- Estimate the ultimate holding capacity of anchor under cyclic loading

See *Section 7.2* for required information to run anchor capacity assessment.

Vessel Characteristics:

Relevant MODU data for mooring analysis is outlined in Section 3.3.3.1 and Section 5.

Mooring Equipment:

The purpose of collecting information on MODU mooring equipment is to determine if there is a high certainty of MODU mooring equipment MBS values.

See *Section 3.3.3.2*, *Section 8* and *Section 9* for information on relevant information.

Step 2 – Determine MODU mooring strategy

Section 3 of the document provides guidance on MODU mooring strategy. The MODU mooring strategy consists of utilising:

1. Conventional moored MODU.
2. SP/RR MODU for evasion of cyclonic metocean conditions.

Step 3 – Determine MODU mooring risk category

Section 3 of the document provides guidance on characterising the MODU mooring risk as either: Low, Medium or High.

The MODU mooring risk is determined by testing against three criteria:

1. Proximity of MODU (drill site) to high value assets (Consequence Test)
2. Season of operation (Likelihood Test)
3. Quality of information available (Risk Mitigation Test)

The first two tests provide an initial risk category. The risk category associated with close proximity mooring can then be reduced by satisfying the third (Risk Mitigation) test. This is the only way that the risk category can be reduced as per the guidance in this document.

The risk mitigation test is based on the information obtained in Step 1.

Step 4 – Review Risk Mitigation Measures and determine metocean Return Period

Each section of the document (*Section 4* to *Section 10*) presents a table of risk mitigation measures which are based on the MODU mooring risk category. It is recommended that the user of this guideline review the risk mitigation tables and consider the mooring recommendations for the relevant MODU mooring risk category. This is recommended be done early in the design stage.

Section 3.3 of the document makes recommendation on the minimum metocean return period with respect to MODU mooring risk category. Satisfying the Risk Mitigation Tests (*Section 3.3.3*) and lowering the risk category (for close proximity moorings) permits the metocean return period to be lowered.

Step 5 – Conduct Mooring Analysis

Section 5 of this report provides guidance on MODU mooring analysis.

If design criteria cannot be satisfied with conventional rig mooring equipment or prelay equipment for the recommended metocean return period, consider:

1. Reduction of metocean return period as outlined in Step 2.
2. Rescheduling drilling operations outside of cyclone season.
3. Utilise a SP/RR MODU.

Step 6 – Conduct Risk Assessment

Section 4 of this report provides guidance on MODU mooring risk assessment.

If the result of the risk assessment shows that the risk is not tolerable, then further risk reduction measures should be considered as per Step 3. When considering further risk reduction measures, the Operator and Titleholder should be satisfied not adopting further risk reductions reduces the MODU mooring risk to as low as reasonably practicable (ALARP).

ALARP needs to be demonstrated even if the MODU mooring risk is considered tolerable by company standards. See *Section 4.6.3* for more information on the demonstration of ALARP as defined by NOPSEMA.

APPENDIX F: FEEDBACK FORM

Please complete details below and email to:

Jason Medd
Director Environment, Health & Safety
jmedd@appea.com.au

Name:		**Position/Title**:	
Email:		**Company**:	
Phone:		**Date**:	

Page	Section no.	Comments/Feedback

APPENDIX G: SUMMARY OF CHANGES MADE IN REVISION 2

The most significant change to this guideline is the inclusion of Self-Propelled MODU's equipped with remote release mooring systems (SP/RR). The following list details the specific sections that have been updated to incorporate Self-Propelled MODU's equipped with remote release mooring systems. Additionally, the guideline has been updated to include the feedback provided by users of the document. Note that not all changes have been listed below. The main changes are:

1 DEFINITIONS AND ABBREVIATIONS

2 INTRODUCTION
2.2 Supporting Mooring Codes and Standards - as API RP 2SK is currently under revision this revision of the guideline is based on the current edition at the time of review (this is the 3rd Edition).

3 RISK SCREENING
3.2 MODU Mooring Strategy & Risk Screening - Update heading title from Philosophy of risk screening to MODU Mooring Strategy & Risk Screening and include consideration for SP/RR MODUs.
3.3.1 Consequence Test – Proximity to assets – expanded on examples of high value assets.
3.3.2 Likelihood Test – Season of operation
3.4 MODU Mooring Risk Category

4 RISK AND ASSURANCE MANAGEMENT
4.3 Objectives - increased details for risk events.

5 MOORING DESIGN AND ANALYSIS
5.1 Basis of Design Requirements – restructured to reflect example provided in Appendix D
5.2.4 Analysis Considerations – changed 6-strands wire rope to any wire rope that has a torque response
5.3 Self-Propelled / Remote Release MODUs
5.4 Metocean Return Period Criteria – Figure 3B

6 METOCEAN
Updated to reflect that the guidelines referenced document [8] is now complete and available via the APPEA webpage.

7 GEOTECHNICAL
7.1 Geology of the NWATW of Australia and Geohazards – remove referenced to anchor manufacturer

8 MOORING EQUIPMENT DESIGN AND MANUFACTURING
Sections 8, 9 and 10 have been restructured to allow better flow of information and to include SP/RR MODUs:
8.1 Scope
8.3 Fibre Rope Mooring Lines - added further information related to potential damage when in contact with seabed.
8.4 Remote Release Mooring Systems
8.5 Risk Based Mitigation Activities - added items related to SP/RR MODUs

9 MOORING EQUIPMENT INSPECTION
Sections 8, 9 and 10 have been restructured to allow better flow of information and to include SP/RR MODUs:
9.2 Equipment Inspection Standards & Procedures - expanded equipment types; added recommended inspection report scope and details; removed GOMO checklist as these were not actually in GOMO.
9.7 Fibre Rope Inspection - corrected referenced Section number for BOD.
9.10 Equipment Storage – Moved from Section 8 to this section. Updated to clarify how storage time should be treated; and final sentence related of storage of fibre ropes.
9.9 Remote Release System Inspection Requirements
9.13 Risk Based Mitigation Activities - Updated mitigation activity recommendations for item 9.11 (ROV inspection post cyclone without failure) to C/R/HR for Low/Med/High risk categories. Also included items related to SP/RR MODUS.

10 MOORING OPERATIONS

Sections 8, 9 and 10 have been restructured to allow better flow of information and to include SP/RR MODUs:

10.5 Mooring Operations Procedures – Heading changed from Mooring Installation & Recovery Procedures as the contents are not just mainly related to installation and recovery.

10.6 Anchor Installation Requirements – included in this section as this is considered part of Operations and also included sub-headings of 10.6.1 Contingencies & 10.6.2Design Tolerance.

10.7 Remote Release System

10.8 Tropical Cyclone Preparation & Response

10.9 Risk Based Mitigation Activities - added items related to SP/RR MODUs

11 REFERENCES

Updated references and included webpage links to NOPSEMA and APPEA documents.