

Design and Analysis of Stationkeeping Systems for Floating Offshore Structures

API RECOMMENDED PRACTICE 2SK
FOURTH EDITION, FEBRUARY 2024



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Contents

1	Scope.....	1
2	Normative References	1
3	Terms, Definitions, Symbols, Acronyms, and Abbreviations	2
3.1	Terms and Definitions	2
3.2	Symbols	6
3.3	Acronyms and Abbreviations	6
4	Stationkeeping Systems and Components.....	7
4.1	Mooring Components.....	7
4.2	Monitoring Equipment.....	9
5	Environmental and Site Data	9
5.1	General.....	9
5.2	Site-specific Data Requirements	10
6	Design and Site Assessment of Stationkeeping Systems.....	11
6.1	General.....	11
6.2	Design Conditions	12
6.3	Installation Considerations at Design Stage.....	21
6.4	Corrosion, Wear, and Abrasion Allowance for Chain	22
6.5	Sheathed and Unsheathed Wire Rope	23
7	Design and Site Assessment Criteria	23
7.1	Safety Factors for Mooring Component Strength	23
7.2	Vessel Position, Offsets, and Heading	27
7.3	Requirements for Clearances	27
7.4	Safety Factors for Mooring Component Fatigue Resistance	31
8	Analysis	32
8.1	General.....	32
8.2	Analysis Methods.....	33
8.3	Coupling Effects.....	34
8.4	Environmental Loads on the Floating Structure	34
8.5	Loads on Mooring Lines and Ropes—Wave and Current Forces	35
8.6	Mooring Analysis for Strength, Offset, and Clearance	36
8.7	Mooring Analysis for Fatigue	37
8.8	Response-based Analysis	40
9	Thruster-assisted Mooring.....	41
9.1	General.....	41
9.2	Use of Thrusters.....	41
9.3	Determination of Allowable Thrust	41
9.4	Failure Modes and Effects Analysis.....	42
10	Installation, Test Load, and As-installed Survey	42
10.1	General	42
10.2	Installation Considerations and Storm-safe Criteria.....	42
10.3	Test Loading Requirements.....	43
10.4	As-installed Survey and Establishment of As-installed Capacity	44
Annex A (informative)	Guidance and Commentary	45
Annex B (normative)	Regional: Gulf of Mexico MODU Mooring Practice for Hurricane Season.....	106
	Bibliography	143

Figures

A.1	Spread Mooring for a Drilling Semisubmersible	46
A.2	Spread Mooring in Catenary or Taut Configurations	46
A.3	External Turret Mooring System (Bow-mounted Type)	47
A.4	Internal Turret Mooring System.....	48
A.5	Disconnectable Turret Mooring System	49
A.6	Catenary Anchor Leg Mooring System with Hawsers	49
A.7	Windlass	51
A.8	Examples of Chain Jacks.....	51
A.9	Fairleads	52
A.10	Typical Fiber Rope Constructions	54
A.11	Typical Wire Rope Constructions	54
A.12	Stud and Studless Chain.....	56
A.13	Examples of Shackle and H-links.....	56
A.14	Stresses and Elongation of Chain Links during Break Test Loading to CBS	62
A.15	High-load Range/Low-cycle Fatigue T-N Curves for Chain, Wire, and Polyester	63
A.16	Examples of Drag Embedment Anchors	70
A.17	Suction Pile.....	71
A.18	Gravity Installed Anchor	72
A.19	Suction Embedded Plate Anchor	73
A.20	Studless Chain Fatigue Test Failures, NEL/ND JIP and TWI JIP	76
A.21	Comparison between API T-N and DNV S-N Fatigue Curves and Fatigue Safety Factors	77
A.22	Comparison between API T-N and DNV S-N Fatigue Curves for a Fatigue Factor of Safety of 1.0.....	78
A.23	Comparison between API T-N and DNV S-N Fatigue Curve Cycles, N , for a Fatigue Factor of Safety of 1.0.....	78
A.24	Examples of Different Wind Velocity Profiles	81
A.25	Illustration of ISO Wind Velocity Profile for Different Wind Speeds.....	81
A.26	Examples of Wind Spectra.....	82
A.27	Comparison of API and ISO (NPD) Spectrum for 25-knot Wind.....	84
A.28	Comparison of API and ISP (NPD) Spectrum for 50-knot Wind	85
A.29	Comparison of API and ISC (NPD) Spectrum for 80-knot Wind.....	85
A.30	Trenching Analysis, Calculation of Distance between Touchdown and Anchor.....	91
A.31	Interlink Stiffness Model Showing Three Phases.....	94
A.32	Interlink Stiffness Model In-air and In-water	94
A.33	Flowchart of a Typical OPB Fatigue Analysis.....	98
A.34	Flowcharts for Response-based Analysis.....	103
B.1	Factor of Safety versus Return Period for Intact Condition.....	109
B.2	Factor of Safety versus Return Period for Damaged Condition	109
B.3	Financial Risk Assessment—Overall Process.....	113
B.4	Metoclon Criteria Flowchart.....	124
B.5	Three Gulf of Mexico Regions	125
B.6	Current Profile for Minimum Category 1 Hurricane Conditions.....	126
B.7	Typical Risk Matrix Used for MODU Mooring Risk Assessment	134
B.8	General Description of MODU and Mooring Location (Part 1) (Example Form).....	138
B.9	As-installed MODU Mooring Information and Condition (Part 2) (Example Form)	139
B.10	As-evacuated MODU Mooring Information and Condition (Part 3) (Example Form)	141
B.11	Post-storm MODU Condition (Part 4) (Example Form)	142

Tables

1	Strength Analysis Cases: Permanent Systems	15
2	Strength Analysis Cases: Mobile Systems	17
3	Offset Analysis Cases: Permanent and Mobile Systems	18
4	Clearance Analysis Cases: Permanent and Mobile Systems	20
5	Fatigue Analysis Cases: Permanent Systems	21
6	Safety Factors for Tensile Strength of Mooring Line Components	24
7	Definitions of Intact and Damaged Conditions for Thruster-assisted Mooring	24
8	Safety Factors for Drag Anchor	25
9	AHC Reduction Factors for Vertically Loaded High-efficiency Drag Anchors in Soft Clay with Deep Penetration	26
10	Safety Factors for Vertically Loaded Plate Anchors	26
11	Safety Factors for Pile Anchors and Gravity Anchors	27
12	Minimum Clearances between Bottom of Suspended Wire or Fiber Rope and Seabed	28
13	Minimum Clearance between Top of the Fiber Rope and Sea Surface	28
14	T-N Fatigue Curve Parameters, m and K, for Use with a Fatigue Safety Factor of 3.0	31
A.1	Permanent Mooring: Example of Project-specific Strength and Seabed Clearances	63
A.2	MODU Mooring: Example of Project-specific Strength and Offset	64
A.3	Examples of Joint Probabilities of Occurrence of Independent Events	67
A.4	Historical Range of Chain Corrosion, Abrasion, and Wear Rates	68
A.5	MPM Peak Factors Example Calculations	90
A.6	List of Facilities with Chain Failure due to OPB Fatigue	92
B.1	Unmitigated Consequence Categories for MODU Operations and Associated Return Periods	114
B.2	Minimum Category 1 Hurricane Conditions	126

Introduction

API standards for the analysis and design of moored vessels have evolved since the first editions of API 2P, API 2FP1, and API 2SK (published in 1984, 1993, and 1995, respectively), and these codes continue to be applicable to the analysis and design of stationkeeping systems that are normally manned and may be occasionally evacuated. The design of mooring systems described herein assumes redundancy, intact and one-line broken cases satisfying the acceptance criteria are required, and therefore it is not applicable to moorings that cannot keep station in one-line broken conditions (such as single-line tethers for buoys or mooring systems with less than five mooring lines in the intact case). For permanent production systems, operating procedures for stationkeeping systems are intended, as a minimum, to include the ability to shut in wells and the facility in an emergency (e.g. emergency shut-down valves on the seabed); otherwise, the consequence of mooring failure could be very different than inherently assumed.

This edition includes several additions and changes. The most significant changes include the following:

- mandatory minimum design requirements are collected in the body of the standard, and informative guidance is included in Annex A;
- Gulf of Mexico hurricane season mobile offshore drilling unit mooring requirements are included in Annex B;
- guidance based on recent technical advances in the offshore industry is also included throughout.

The Fourth Edition of API 2SK also represents an umbrella document for stationkeeping system design, which is supported by additional guidance or specifications of stationkeeping system components, such as environmental criteria, anchor design, inspection, and integrity management. These supporting documents include (to address the described interest):

- API 2MET (environmental conditions a moored stationkeeping system is exposed to);
- API 2SM (determination of fiber rope properties for design analysis);
- API 2I (inspection of moored stationkeeping systems and components);
- ISO 19901-4 (geotechnical aspects of anchor designs for stationkeeping systems);
- API 2MIM (integrity management of moored stationkeeping systems);
- API 2F (chain specification for moored stationkeeping systems);
- API 9A (wire rope elements of a moored stationkeeping system);
- API 2S (mooring fairleads or windlasses for a moored stationkeeping system).

The technology of moored floating units continues to develop. In those areas where adequate data are available, specific and detailed recommendations are given. In other areas, general statements are used to indicate where it is intended for consideration to be given to those particular design aspects. Designers are encouraged to utilize research advances available to them.

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Design and Analysis of Stationkeeping Systems for Floating Offshore Structures

1 Scope

This standard addresses the design and analysis of stationkeeping systems (mooring systems with or without thruster assistance) in conditions from survival to operational. Different design requirements for mobile and permanent moorings are provided.

The procedures for the design or site assessment of mobile mooring systems specified in this document are based on a deterministic approach where mooring system responses, such as line tensions, vessel offsets, and anchor loads, are evaluated for a design environment defined by an annual probability of occurrence or return period. Mooring system responses are then checked against acceptance criteria for mooring strength, offsets and orientation, clearances, anchor capacity, fatigue resistance, and so forth. The minimum acceptance criteria are either defined in this standard or are to be specified by the owner or the operator.

For moored vessels, system responses are calculated and compared to acceptance criteria for limit states describing acceptable extreme loads (line tensions), vessel offsets (translation and rotation), clearances (vessel, risers, water surface, seabed, anchors, field infrastructure, etc.), and fatigue (cumulative mooring component fatigue damage). Limit states associated with the extremes of the vessel's first order wave-frequency motions (surge, sway, heave, roll, pitch, and yaw at a particular point on the vessel), such as serviceability of machinery, heave compensators, separators, tank sloshing, motion-sickness, etc., exist; however, they are not addressed by this standard.

The requirements of this standard mainly address spread and single-point mooring systems with mooring lines composed of chain, wire rope, fiber rope, or a combination of these. This standard is applicable to the following types of stationkeeping systems:

- spread moorings;
- single-point moorings, anchored by spread mooring arrangements;
- thruster-assisted moorings (TAMs).

NOTE Guidance on the design and operation of dynamically positioned vessels is contained in IMCA M103.

This standard is not applicable to the vertical tendons found on tension-leg platforms (TLPs), which are covered by API 2T. Parts of this standard may not be appropriate for stationkeeping systems that are normally unmanned and occasionally manned (such as wind farms) or normally unmanned floating facilities. API 2SM, API 2I, and API 2MIM provide more detailed guidance on fiber ropes, mooring inspection, and integrity management.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the cited edition applies. For undated references, the latest edition of the referenced document (including any addenda or errata) applies.

API Recommended Practice 2A-WSD, *Planning, Designing, and Constructing Fixed Offshore Platforms—Working Stress Design*

API Recommended Practice 2I, *In-Service Inspection of Mooring Hardware for Floating Structures*

API Recommended Practice 2MET, *Derivation of Metocean Design and Operating Conditions*