Design, Manufacture, Installation, and Maintenance of Synthetic Fiber Ropes for Offshore Mooring

API RECOMMENDED PRACTICE 2SM
SECOND EDITION, JULY 2014

REAFFIRMED, JUNE 2025



Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

Users of this Recommended Practice should not rely exclusively on the information contained in this document. Sound business, scientific, engineering, and safety judgment should be used in employing the information contained herein.

All rights reserved. No part of this work may be reproduced, translated, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the Publisher, API Publishing Services, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001.

Copyright © 2014 American Petroleum Institute

Foreword

API 2SM is under the jurisdiction of the API Subcommittee on Offshore Structures. The main purpose of this document is to provide guidelines on the use of synthetic fiber ropes for offshore mooring applications. The secondary purpose of this document is to highlight differences between synthetic rope and traditional steel mooring systems, and to provide practical guidance on how to handle these differences during system design and installation.

The contents of this document should be used in conjunction with the most recent editions of API 2SK and API 2I, and other recommended practices and standards, as appropriate. Where the mooring design, construction and installation details are similar or equivalent to steel mooring systems, no further comments are included in this document.

This document reflects the latest learning from research, design, installation, and operation of synthetic fiber mooring components. The technology in synthetic fiber rope moorings continues to evolve. Designers are advised to take appropriate measures to ensure that their practices incorporate all research advances available to them.

The verbal forms used to express the provisions in this specification are as follows:

— the term "shall" denotes a minimum requirement to conform to the specification;

— the term "should" denotes a recommendation or that which is advised but not required to conform to the specification;

— the term "may" is used to express permission or a provision that is optional;

— the term "can" is used to express possibility or capability.

Nothing contained in any API publication is to be construed as granting any right, by implication or otherwise, for the manufacture, sale, or use of any method, apparatus, or product covered by letters patent. Neither should anything contained in the publication be construed as insuring anyone against liability for infringement of letters patent.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Generally, API standards are reviewed and revised, reaffirmed, or withdrawn at least every five years. A one-time extension of up to two years may be added to this review cycle. Status of the publication can be ascertained from the API Standards Department, telephone (202) 682-8000. A catalog of API publications and materials is published annually by API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001.

Suggested revisions are invited and should be submitted to the Standards Department, API, 200 Massachusetts Avenue, NW, Suite 1100, Washington, DC 20001, standards@api.org.

Contents

Page

1 Scope . . . 1

2 Normative References . . . 1

3 Terms, Definitions, Symbols, and Abbreviations . . . 2
3.1 Terms and Definitions . . . 2
3.2 Symbols and Abbreviations . . . 8

4 Basic Considerations . . . 9
4.1 General . . . 9
4.2 Synthetic Fiber Ropes for Offshore Mooring . . . 9
4.3 Main Characteristics of Synthetic Fiber Ropes . . . 10

5 Rope Design and Properties . . . 11
5.1 General . . . 11
5.2 Rope Material . . . 11
5.3 Rope Construction . . . 13
5.4 Rope Filter Barrier and Jacket . . . 13
5.5 Rope Termination . . . 14
5.6 Rope Properties . . . 15

6 Mooring Design and Analysis . . . 21
6.1 General . . . 21
6.2 Mooring Configuration and Design . . . 21
6.3 Design Criteria . . . 22
6.4 Mooring Analysis . . . 23
6.5 Model Testing . . . 31

7 Rope Specification and Testing . . . 31
7.1 General . . . 31
7.2 Rope Specification and Documentation . . . 31
7.3 Rope Testing . . . 37

8 Rope Manufacture, Inspection, and Quality Assurance . . . 40
8.1 General . . . 40
8.2 Rope Fiber Material . . . 40
8.3 Rope Manufacturing . . . 42
8.4 Termination . . . 42
8.5 Assembly . . . 42
8.6 Inspection . . . 43
8.7 Quality Control and Assurance . . . 44

9 Rope Storage, Handling and Installation . . . 45
9.1 General . . . 45
9.2 Storage, Handling, and Installation Specifications . . . 45
9.3 Storage, Handling, and Installation Considerations . . . 46
9.4 Installation Design Considerations . . . 49
9.5 Installation/Recovery Procedures . . . 54

10 In-service Inspection and Maintenance . . . 56
10.1 General . . . 56
10.2 Destructive Inspection of Inserts . . . 56
10.3 Operations . . . 56

Contents

Page

Annex A (normative) **Filter Barrier Particle Ingress Test** 57

Annex B (normative) **Testing of Rope Load-elongation Properties** 59

Annex C (normative) **Torque and Rotation Tests** 86

Annex D (normative) **Testing of Rope Tension-tension Fatigue Qualification** 88

Annex E (normative) **Testing of Rope Strength** 90

Annex F (normative) **Testing of Rope Axial Compression Performance** 92

Annex G (informative) **Polyester Mooring Analysis Example** 94

Figures

1 Polyester Durability JIP, OTC 5720 and Fiber Tethers 2000 Fatigue Test Data, Compared with Wire Rope and Chain TN Curves from API 2SK 19
2 Polyester Rope Load-Elongation: Load-vs.-Extensometer 24
3 Idealized Polyester Behavior 26
4 Diagram of Eye Splice Showing Features 35
5 Typical Reel and Lifting Arrangement 47
6 Surface Buoys Tensioned Together to Maintain Fiber Rope in Tension 53
A.1 Grading of Sand for Particle Ingress Resistance Test 58
B.1 Idealized Synthetic Rope Elongation Behavior 61
B.2 Quasi-static Stiffness 73
B.3 Strain Component for DES/DER/Creep Test 85
G.1 Mooring Pattern for Identical Eight Line Equally Spaced Mooring System 95
G.2 Linear and Nonlinear Polyester Load-elongation Models 96
G.3 Maximum Vessel Offset, Nonlinear and Linear Load-elongation Curves 99
G.4 Maximum Tensions, Nonlinear and Linear Load-elongation Curves 100
G.5 Polyester Rope Delayed and Recoverable Elastic Stretch 101
G.6 Maximum Vessel Offsets for Three Nonlinear Moorings—Cases 1, 2-a, and 2-b 104
G.7 Maximum Tensions for Three Nonlinear Moorings—Cases 1, 2-a, and 2-b 104

Tables

1 Fiber Properties 11
2 Typical Rope Weights and Sizes for 10,000 kN Break Strength (including Jacket) 16
3 Typical Stiffness Values in EA/CBS 17
4 Fiber Rope Fatigue Curve Qualification Test Cycles 39
5 Resistance to Chemical and UV Radiation Damage 47
G.1 Mooring Line Properties, Eight Identical Lines 95
G.2 Anchor Distances and Grounded Lengths for Pretensions of 250 kips 96
G.3 Hurricane Metocean Conditions and Mean Loads for Return Periods between 5 and 40 Years 97
G.4 Maximum Vessel Offsets and Tensions—Nonlinear Load-Elongation Curves 98
G.5 Vessel Offsets for Four Linear Load-Elongation Curves 99
G.6 Un-stretched Total Polyester Rope Lengths, Outboard Wire Rope Lengths, and Pretensions for Three Moorings 102
G.7 Quiescent Equilibrium Vessel Offsets for Three Moorings 103
G.8 Maximum Vessel Offsets and Tensions for Three Moorings 103

Design, Manufacture, Installation, and Maintenance of Synthetic Fiber Ropes for Offshore Mooring

1 Scope

1.1 This document applies to synthetic fiber ropes used in the form of taut leg or catenary moorings for both permanent and temporary offshore installations such as:

a) monohull-based floating production, storage, and offloading units (FPSOs);

b) monohull-based floating storage units (FSOs, FSUs);

c) monohull or semi-submersible based floating production units (FPUs, FPSs);

d) mobile offshore drilling units (MODUs);

e) spar platforms;

f) catenary anchor leg mooring (CALM) buoys (spread mooring only);

g) mobile offshore units (MOUs, e.g., construction, pipelay, floating accommodation vessels).

1.2 This document covers the following aspects of synthetic fiber ropes:

a) design and analysis considerations of mooring system;

b) design criteria for mooring components;

c) rope design;

d) rope specification and testing;

e) rope manufacture and quality assurance;

f) rope handling and installation;

g) in-service inspection and maintenance.

1.3 Application of this document to other offshore mooring applications is at the discretion of the designer and operator. This document is not intended to cover other marine applications of synthetic fiber ropes such as tanker mooring at piers and harbors, towing hawsers, mooring hawsers at single-point moorings (SPMs), and tension leg platform (TLP) tethers. Additionally, very little test data are available for large synthetic fiber ropes permanently deployed around fairleads and thus this document is limited to fiber ropes which span freely between end terminations.

2 Normative References

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

API RP 2I, *In-Service Inspection of Mooring Hardware for Floating Drilling Units*

API RP 2SK, *Design and Analysis of Stationkeeping Systems for Floating Structures*