Offshore fibre ropes
FOREWORD

DNV GL offshore standards contain technical requirements, principles and acceptance criteria related to classification of offshore units.

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Any comments may be sent by e-mail to rules@dnvgl.com
CHANGES – CURRENT

General
This document supersedes DNV-OS-E303, February 2013.

Text affected by the main changes in this edition is highlighted in red colour. However, if the changes involve a whole chapter, section or sub-section, normally only the title will be in red colour.

On 12 September 2013, DNV and GL merged to form DNV GL Group. On 25 November 2013 Det Norske Veritas AS became the 100% shareholder of Germanischer Lloyd SE, the parent company of the GL Group, and on 27 November 2013 Det Norske Veritas AS, company registration number 945 748 931, changed its name to DNV GL AS. For further information, see www.dnvgl.com. Any reference in this document to “Det Norske Veritas AS”, “Det Norske Veritas”, “DNV”, “GL”, “Germanischer Lloyd SE”, “GL Group” or any other legal entity name or trading name presently owned by the DNV GL Group shall therefore also be considered a reference to "DNV GL AS".

Main changes July 2015

• General
The revision of this document is part of the DNV GL merger, updating the previous DNV standard into a DNV GL format including updated nomenclature and document reference numbering, e.g.:
— Main class identification 1A1 becomes 1A.
— DNV replaced by DNV GL.
— DNV-RP-A201 to DNVGL-CG-0168. A complete listing with updated reference numbers can be found on DNV GL's homepage on internet.

To complete your understanding, observe that the entire DNV GL update process will be implemented sequentially. Hence, for some of the references, still the legacy DNV documents apply and are explicitly indicated as such, e.g.: Rules for Ships has become DNV Rules for Ships.

There is no change in the technical or documentation requirements from DNV-OS-E303, February 2013.

The structure of this document has been converted to decimal numbering. Older references to this document may normally be interpreted by analogy to this example:
— “Ch.2 Sec.3 D506” is now “Ch.2 Sec.3 [4.5.6]”.

• Ch.1 Sec.1
In [4] Safe Service Assessment has been re-named to 3-T utilisation assessment.

• Ch.2 Sec.5
— Table 1: Reference to 'change-in-length' has been updated as “specified by the client”.
— In [4.1.3] and [4.2.2] it is emphasised that the rope manufacturer is responsible for defining the load case.

• Ch.3 Sec.2
In [7] the description of certification requirements has been simplified.

• Previous Appendices B to E
Appendices showing examples of certificates have been removed.

Editorial corrections
In addition to the above stated main changes, editorial corrections may have been made.
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CHANGES – CURRENT</td>
<td>3</td>
</tr>
<tr>
<td>CH. 1</td>
<td>INTRODUCTION</td>
<td>7</td>
</tr>
<tr>
<td>Sec. 1</td>
<td>General</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>About this standard</td>
<td>7</td>
</tr>
<tr>
<td>1.1</td>
<td>Introduction</td>
<td>7</td>
</tr>
<tr>
<td>1.2</td>
<td>Objective</td>
<td>7</td>
</tr>
<tr>
<td>1.3</td>
<td>Structure</td>
<td>7</td>
</tr>
<tr>
<td>2</td>
<td>Scope of this standard</td>
<td>7</td>
</tr>
<tr>
<td>2.1</td>
<td>General</td>
<td>7</td>
</tr>
<tr>
<td>2.2</td>
<td>Application areas</td>
<td>7</td>
</tr>
<tr>
<td>2.3</td>
<td>Mooring applications</td>
<td>8</td>
</tr>
<tr>
<td>2.4</td>
<td>Underwater deployment and recovery applications</td>
<td>8</td>
</tr>
<tr>
<td>2.5</td>
<td>Types of offshore fibre ropes and tethers</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>References</td>
<td>8</td>
</tr>
<tr>
<td>3.1</td>
<td>General</td>
<td>8</td>
</tr>
<tr>
<td>3.2</td>
<td>Normative references</td>
<td>9</td>
</tr>
<tr>
<td>3.3</td>
<td>Informative references</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>Definitions</td>
<td>10</td>
</tr>
<tr>
<td>4.1</td>
<td>Verbal forms</td>
<td>10</td>
</tr>
<tr>
<td>4.2</td>
<td>Terms</td>
<td>10</td>
</tr>
<tr>
<td>CH. 2</td>
<td>REQUIREMENTS</td>
<td>14</td>
</tr>
<tr>
<td>Sec. 1</td>
<td>General</td>
<td>14</td>
</tr>
<tr>
<td>1</td>
<td>Introduction</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>Marking</td>
<td>14</td>
</tr>
<tr>
<td>2.1</td>
<td>General</td>
<td>14</td>
</tr>
<tr>
<td>2.2</td>
<td>Twist marker</td>
<td>14</td>
</tr>
<tr>
<td>3</td>
<td>Transport</td>
<td>14</td>
</tr>
<tr>
<td>3.1</td>
<td>General</td>
<td>14</td>
</tr>
<tr>
<td>4</td>
<td>Service</td>
<td>14</td>
</tr>
<tr>
<td>4.1</td>
<td>General</td>
<td>14</td>
</tr>
<tr>
<td>4.2</td>
<td>Protection cloth for spliced eyes</td>
<td>14</td>
</tr>
<tr>
<td>4.3</td>
<td>Offshore mooring</td>
<td>15</td>
</tr>
<tr>
<td>4.4</td>
<td>Underwater deployment and recovery</td>
<td>15</td>
</tr>
<tr>
<td>5</td>
<td>Condition management</td>
<td>15</td>
</tr>
<tr>
<td>5.1</td>
<td>General</td>
<td>15</td>
</tr>
<tr>
<td>5.2</td>
<td>High tension</td>
<td>16</td>
</tr>
<tr>
<td>5.3</td>
<td>Test material</td>
<td>16</td>
</tr>
<tr>
<td>5.4</td>
<td>Repair</td>
<td>16</td>
</tr>
<tr>
<td>6</td>
<td>Design</td>
<td>16</td>
</tr>
<tr>
<td>6.1</td>
<td>Load-bearing yarn</td>
<td>16</td>
</tr>
<tr>
<td>6.2</td>
<td>Rope construction</td>
<td>17</td>
</tr>
<tr>
<td>6.3</td>
<td>Terminations</td>
<td>17</td>
</tr>
<tr>
<td>Sec. 2</td>
<td>Requirements to materials</td>
<td>18</td>
</tr>
<tr>
<td>1</td>
<td>Load-bearing yarn</td>
<td>18</td>
</tr>
<tr>
<td>1.1</td>
<td>General</td>
<td>18</td>
</tr>
</tbody>
</table>
Sec.3 Performance characteristics

1 Introduction .................................................................................20
  1.1 General ...................................................................................20

2 Load-bearing yarn ........................................................................20
  2.1 General ...................................................................................20

3 Fibre-rope or fibre-tether segment ...................................................20
  3.1 Tension-time-temperature performance characteristics (3-T).........20
  3.2 Cyclic endurance ......................................................................20
  3.3 Splice integrity .........................................................................21
  3.4 Change-in-length characteristics .............................................21
  3.5 Torque and twist characteristics ..............................................21
  3.6 Breaking strength .....................................................................21
  3.7 Resistance to soil ingress of mooring lines.................................22
  3.8 Hysteresis heating ....................................................................22
  3.9 Low-tension durability ..............................................................22

4 Termination hardware ....................................................................22
  4.1 General ...................................................................................22

Sec.4 Design verification .........................................................................23

1 Documentation requirements ..........................................................23
  1.1 General ...................................................................................23
  1.2 System integrator ......................................................................23
  1.3 Rope manufacturer ...................................................................24
  1.4 Yarn manufacturers ..................................................................25
  1.5 Termination hardware manufacturers .......................................25

Sec.5 Testing of deliveries .....................................................................27

1 Introduction ...................................................................................27
  1.1 General ...................................................................................27

2 Testing of load-bearing yarn ..........................................................27
  2.1 General ...................................................................................27

3 Testing of rope and tether ...............................................................28
  3.1 General ...................................................................................28
  3.2 Offshore mooring ......................................................................28
  3.3 Testing of maximum temperature due to hysteresis heating in mooring lines ........................................29
  3.4 Deepwater deployment and recovery .........................................29

4 Test methods ..................................................................................29
  4.1 General ...................................................................................29
  4.2 Termination hardware ...............................................................29
  4.3 Materials testing of termination hardware ..................................30

CH. 3 CLASSIFICATION AND CERTIFICATION .........................31

Sec.1 Classification and certification ....................................................31
  1 Classification ..............................................................................31
    1.1 Introduction ..........................................................................31
2 Certification............................................................................................31
   2.1 General...........................................................................................31
   2.2 Main elements in certification .........................................................31
   2.3 Approval of manufacturer ...............................................................31
   2.4 Deviations and test waivers ...........................................................31
   2.5 Design verification .........................................................................32
   2.6 Survey during manufacture ...........................................................32
3 Certification of yarns .............................................................................32
   3.1 Load-bearing yarns .......................................................................32
   3.2 Non-load-bearing components ......................................................32
4 Certification of termination hardware.....................................................32
   4.1 General...........................................................................................32
5 Certification of lines................................................................................33
   5.1 Introduction ....................................................................................33
6 Special service........................................................................................33
   6.1 General...........................................................................................33
   6.2 Sea-bed contact ............................................................................33
   6.3 External contact ............................................................................33
7 Re-certification of offshore fibre ropes and tethers ................................33
   7.1 General...........................................................................................33
Sec.2 Work process for certification of lines.........................................................35
1 General ...................................................................................................35
   1.1 Introduction ....................................................................................35
   1.2 Request for certification .................................................................35
   1.3 Pre-production meeting .................................................................35
2 Design verification..................................................................................36
   2.1 General...........................................................................................36
3 Design verification report ......................................................................36
4 Start-up of production ...........................................................................36
5 Survey during production and testing ....................................................37
   5.1 Scope of survey ............................................................................37
6 Testing ...................................................................................................37
   6.1 General...........................................................................................37
7 Certificates .............................................................................................37
   7.1 Certificates for load-bearing yarns ..................................................37
   7.2 Certificates for termination hardware ............................................37
   7.3 Certificates for offshore fibre ropes and offshore fibre tethers ............37
APP. A SCOPE OF SURVEY AT ROPE MANUFACTURER ........ 38
CHAPTER 1 INTRODUCTION

SECTION 1 GENERAL

1 About this standard

1.1 Introduction

1.1.1 This Standard covers technical requirements to offshore fibre ropes and offshore fibre tethers, and requirements to documentation for verification and certification.

1.1.2 The current, official issue of this standard and other DNV GL service documents are available at www.dnvgl.com

Guidance note:
This standard will be developed further. Readers are encouraged to provide their comments and input to ‘rules@dnvgl.com’ as the document will be continually developed.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.2 Objective

The objective of this standard is to ensure that the design and manufactured quality of offshore fibre ropes and offshore fibre tethers meet the requirements of designated locations, handling and service scenarios for offshore applications, as basis for ensuring reliable offshore systems that use load-bearing lines made from synthetic fibre materials.

1.3 Structure

Chapter 1 (this chapter) provides a general introduction with overview, definitions, general provisions and references relevant for Ch.2 and Ch.3. Ch.2 provides the requirements of this standard. Ch.3 covers the process of certification.

1.3.1 It has been attempted to structure Ch.2 to reflect the logical sequence of defining and verifying the right product for a given application. Information which is general to all variants and applications of offshore fibre ropes and tethers is presented first, then application-specific and design-specific information.

1.3.2 Requirements pertaining to the service phase and condition management are thus presented prior to requirements pertaining to design and requirements to materials.

2 Scope of this standard

2.1 General

2.1.1 This standard provides requirements to materials, design, manufacture and testing of offshore fibre ropes and tethers, which are subject to verification or certification.

2.1.2 It may also serve as a technical reference document in contractual matters between system integrator and manufacturer.

2.2 Application areas

2.2.1 This standard is applicable to service scenarios which render sufficient 3-T performance margins for the load-bearing yarns in the line, and where the variation in loading is within the maximum design range of the load-bearing yarn.

Guidance note:
The tests in the yarn approval programme are tailored at showing that tension variations within the design range do not affect the 3-T performance margins of the yarn. Other reasons for managing the design range may exist and shall be accounted for in the design.
2.2.2 It is applicable to offshore fibre ropes and tethers in the following applications with loading in tension:

- Taut mooring of offshore units.
- Semi-taut and catenary moorings where only a portion contains fibre line.

2.2.3 It is further applicable to the following applications with combined loading, i.e. with bending or twisting in addition to tension:

- Mooring systems where elements generate torque and twist.
- Underwater deployment and recovery applications.

2.2.4 The documentation requirements of this standard can further be applied to the following other applications where the technical requirements should be established on a case-by-case basis:

- Tension leg platforms (TLP)
- Synthetic-fibre elements for lifting
- Towlines

Guidance note:
For the TLP tether application, due consideration shall be given to definition of the load cases, including that of around-axis rotation of the platform (yaw). The susceptibility of the tether system to cutting by external objects shall be considered, and the redundancy of the design shall be described.

2.3 Mooring applications
Typical mooring applications are anchoring of long-term floating production systems and anchoring systems for mobile offshore units. This standard is applicable to synthetic fibre mooring lines for other offshore installations, such as wave-, wind-, or current energy plant.

2.4 Underwater deployment and recovery applications
Reference is made to DNV-OS-E407 for more information.

2.5 Types of offshore fibre ropes and tethers
This standard covers offshore fibre ropes and offshore fibre tethers that are manufactured using aramid, polyester, HMPE, LCP, or polyamide (nylon) materials for the load-bearing yarns.

Guidance note:
Offshore fibre ropes and tethers can be manufactured in braided or helical arrangement of the strands (construction). The built-in twist of the strands will depend on the production method. Tethers can also be constructed by many parallel, load-bearing elements with an external jacket.
Other load-bearing fibre materials than those stated, including combinations, can be considered on a case-by-case basis.
More information about types of offshore fibre ropes and tethers is provided in DNVGL-RP-E305.

3 References

3.1 General

3.1.1 In case of conflict between requirements of this standard and a reference document, the requirements of this standard shall prevail.

3.1.2 The latest edition of the referenced document (including amendments) should apply.
3.2 Normative references
The referenced documents listed in Table 1 through Table 4 include provisions, which through reference in the text constitute requirement of this standard.

Table 1 DNV GL / DNV Offshore Standards

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNVGL-OS-B101</td>
<td>Metallic materials</td>
</tr>
<tr>
<td>DNVGL-OS-C401</td>
<td>Fabrication and testing of offshore structures</td>
</tr>
<tr>
<td>DNVGL-OS-E301</td>
<td>Position mooring</td>
</tr>
<tr>
<td>DNVGL-OS-E302</td>
<td>Offshore mooring chain</td>
</tr>
<tr>
<td>DNVGL-OS-E304</td>
<td>Offshore mooring steel wire ropes</td>
</tr>
<tr>
<td>DNV-OS-E407</td>
<td>Underwater deployment and recovery systems</td>
</tr>
</tbody>
</table>

Table 2 DNV Programmes for approval of manufacturers

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>321</td>
<td>Manufacturers of Offshore Fibre Ropes</td>
</tr>
<tr>
<td>322</td>
<td>Manufacturers of Offshore Fibre Yarns</td>
</tr>
</tbody>
</table>

Table 3 DNV Recommended Practices

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNV-RP-A203</td>
<td>Technology qualification</td>
</tr>
</tbody>
</table>

Table 4 Other References

<table>
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<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CI 1503</td>
<td>Test Method for Yarn-on-Yarn Abrasion</td>
</tr>
<tr>
<td>ISO 3344</td>
<td>Reinforcement products - Determination of moisture content</td>
</tr>
<tr>
<td>EN 10204</td>
<td>Metallic products - Types of inspection documents</td>
</tr>
</tbody>
</table>

3.3 Informative references
The referenced documents listed in Table 5 through Table 9 may be useful to the users of this standard.

Table 5 DNV Offshore Standards

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
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</thead>
<tbody>
<tr>
<td>DNV-OS-C501</td>
<td>Composite Components</td>
</tr>
<tr>
<td>DNV-OS-H203</td>
<td>Transit and Positioning of Offshore Units</td>
</tr>
</tbody>
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Table 6 DNV GL Rules for classification - Mobile units

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNVGL-RU-OU-0101</td>
<td>Offshore drilling and support units</td>
</tr>
<tr>
<td>DNVGL-RU-OU-0102</td>
<td>Floating production, storage and loading units</td>
</tr>
<tr>
<td>DNVGL-RU-OU-0103</td>
<td>Floating LNG/LPG production, storage and loading units</td>
</tr>
</tbody>
</table>

Table 7 DNV GL Service specifications

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNVGL-SE-0160</td>
<td>Independent qualification of equipment, devices and facilities for designated service</td>
</tr>
</tbody>
</table>

Table 8 DNV GL / DNV Recommended practices

<table>
<thead>
<tr>
<th>Reference</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNV-RP-E304</td>
<td>Damage assessment of fibre ropes for offshore mooring</td>
</tr>
<tr>
<td>DNVGL-RP-E305</td>
<td>Design, testing and analysis of offshore fibre ropes</td>
</tr>
</tbody>
</table>
4 Definitions

4.1 Verbal forms

The following verbal forms are used in this document.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>shall</td>
<td>verbal form used to indicate requirements strictly to be followed in order to conform to the document</td>
</tr>
<tr>
<td>should</td>
<td>verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required</td>
</tr>
<tr>
<td>may</td>
<td>verbal form used to indicate a course of action permissible within the limits of the document</td>
</tr>
<tr>
<td>can</td>
<td>a conditional possibility.</td>
</tr>
</tbody>
</table>

4.2 Terms

The terms that are applicable to this standard are provided below.

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-T</td>
<td>the load-bearing capability of synthetic-yarn materials is referred to as 3-T (endurance) since it depends on the combination of the critical parameters ‘tension’, ‘temperature’ and ‘time’</td>
</tr>
<tr>
<td>Guidance note:</td>
<td>As the criticality of each parameter depends on the other two critical parameters, all three can be seen as a single, three-dimensional, critical parameter called 3-T. See DNV-RP-A203 for definition and explanation of critical parameters.</td>
</tr>
<tr>
<td>Change-in-length performance</td>
<td>the length and dynamic stiffness of the fibre rope/tether as function of loading sequence and time</td>
</tr>
<tr>
<td>Guidance note:</td>
<td>The dynamic stiffness changes with mean-tension and amplitude of loading, and loading history.</td>
</tr>
<tr>
<td>Combined loading</td>
<td>in addition to axial loading, combined loading includes bending or twisting</td>
</tr>
<tr>
<td>Condition management programme</td>
<td>inspection plan, measurements and activities performed regularly during the service life in order to assure the condition of the offshore fibre rope or tether</td>
</tr>
</tbody>
</table>
Table 11 Terms (Continued)

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>core</td>
<td>a parallel bundle of load-bearing elements (e.g. subropes) in an offshore fibre tether</td>
</tr>
<tr>
<td>creep failure</td>
<td>the transition between stage II and stage III creep for HMPE load-bearing fibre</td>
</tr>
<tr>
<td>cyclic endurance</td>
<td>the ability to withstand prolonged cyclic loading with a controlled effect on the performance characteristics</td>
</tr>
<tr>
<td>DDRS</td>
<td>Deepwater deployment and recovery system; see DNV-OS-E407</td>
</tr>
<tr>
<td>design range</td>
<td>the difference between the highest occurring tension and the lowest occurring tension in the fibre rope/tether</td>
</tr>
<tr>
<td>design verification report (DVR)</td>
<td>report issued by the independent verifier after review and evaluation of the design documentation</td>
</tr>
<tr>
<td>dtex</td>
<td>a measurement unit for linear density, i.e. weight per unit length of textiles: ( \text{tex} = 10^{-3} \times \text{g/m}, \text{dtex} = 10^{-4} \times \text{g/m}, \text{ktex} = \text{g/m}, \text{and} \text{Mtex} = \text{kg/m} )</td>
</tr>
<tr>
<td>dynamic stiffness</td>
<td>the stiffness of a rope/tether subjected to harmonic or irregular cyclic tension variations</td>
</tr>
<tr>
<td>FEM</td>
<td>Finite element modelling</td>
</tr>
<tr>
<td>fibre rope</td>
<td>the free length of rope (and sheathing as applicable), excluding terminations (splices and eyes) and termination hardware</td>
</tr>
<tr>
<td>fibre-rope segment</td>
<td>fibre rope with terminations, excluding termination hardware</td>
</tr>
<tr>
<td>fibre tether</td>
<td>the load-bearing core with sheathing, excluding terminations (splices and eyes) and termination hardware</td>
</tr>
<tr>
<td>fibre-tether segment</td>
<td>fibre tether with terminations, excluding termination hardware</td>
</tr>
<tr>
<td>filter</td>
<td>a barrier towards ingestion of foreign matter, which is applied underneath the jacket</td>
</tr>
<tr>
<td>Guidance note</td>
<td>advice which is not mandatory under this standard, but with which DNV, in light of general experience, advises compliance The reader may decide whether to apply the note or not. Guidance Notes can also contain statements provided for additional information.</td>
</tr>
<tr>
<td>HMPE</td>
<td>high-modulus polyethylene</td>
</tr>
<tr>
<td>insert</td>
<td>a short segment that is intended to be retrieved from a mooring system as test material to assess the condition during service It can also be a cut off from a long line which is re-spliced and returned to service upon retrieval of the test length.</td>
</tr>
<tr>
<td>ITP</td>
<td>inspection and test plan, which is a plan for the various steps in making the offshore fibre ropes or tethers, describing the involvement of QA department and independent verifier</td>
</tr>
<tr>
<td>ktex</td>
<td>a measurement unit for linear density, i.e. weight per unit length of textiles: ( \text{tex} = 10^{-3} \times \text{g/m}, \text{dtex} = 10^{-4} \times \text{g/m}, \text{ktex} = \text{g/m}, \text{and} \text{Mtex} = \text{kg/m} )</td>
</tr>
<tr>
<td>line</td>
<td>fibre-rope or fibre-tether segment with designated termination hardware</td>
</tr>
<tr>
<td>long-term mooring</td>
<td>anchoring of a unit at the same location for more than 5 years</td>
</tr>
<tr>
<td>long-term mooring system</td>
<td>mooring system that is installed for a design life of five years or more</td>
</tr>
<tr>
<td>marine grade of yarn</td>
<td>yarns that through adequate processing and treatment is deemed fit for service in marine applications and offshore mooring, and where this is documented by testing</td>
</tr>
<tr>
<td>MBS</td>
<td>the minimum breaking strength is the specified or stated minimum strength of the rope, which is verified by testing under certain conditions Guidance note: Minimum breaking strength is not a property. It is not considered to be a key performance characteristic under this standard.</td>
</tr>
<tr>
<td>MLA</td>
<td>mechanical lifting appliance; see DNV-OS-E407</td>
</tr>
<tr>
<td>mobile mooring</td>
<td>anchoring at a specific location for a period less than 5 years</td>
</tr>
<tr>
<td>mobile mooring system</td>
<td>mooring system with a design life of less than five years, or a mooring system utilised by mobile units such as Mobile Offshore Drilling Units; characterised by intermittent use of the mooring lines that allows hands-on inspection at limited time intervals</td>
</tr>
<tr>
<td>Mtex</td>
<td>a measurement unit for linear density, i.e. weight per unit length of textiles: ( \text{tex} = 10^{-3} \times \text{g/m}, \text{dtex} = 10^{-4} \times \text{g/m}, \text{ktex} = \text{g/m}, \text{and} \text{Mtex} = \text{kg/m} )</td>
</tr>
</tbody>
</table>
### Table 11 Terms (Continued)

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>nominal load-bearing linear density (NLLD)</td>
<td>the aggregate linear density of the load-bearing yarns as stated by the yarn manufacturer</td>
</tr>
<tr>
<td></td>
<td>Guidance note:</td>
</tr>
<tr>
<td></td>
<td>There is no testing of rope or tether required to determine nominal load-bearing linear density.</td>
</tr>
<tr>
<td>offshore fibre rope</td>
<td>a synthetic-fibre line tailored for offshore application under tension with or without bending</td>
</tr>
<tr>
<td>offshore fibre tether</td>
<td>a synthetic-fibre line tailored for offshore application under tension without bending</td>
</tr>
<tr>
<td>offshore fibre yarn</td>
<td>yarns that through adequate processing and treatment is fit for service as load-bearing yarns in offshore fibre ropes and tethers</td>
</tr>
<tr>
<td>original length</td>
<td>the length of the fibre rope or tether as it has been produced</td>
</tr>
<tr>
<td></td>
<td>It is measured after a minimum of 17 minutes at reference tension, either as the gauge length during testing, or as the original length during the process of manufacturing for delivery. It is assumed that subropes have not been pre stretched prior to over-braiding, in which case original length should be based on the pristine subropes prior to pre stretching which will otherwise affect the original curve.</td>
</tr>
<tr>
<td>performance characteristics</td>
<td>the properties that define the margins towards failure for each failure mode, and the properties that describe how the line performs in the application</td>
</tr>
<tr>
<td>reference tension</td>
<td>a constant tension of 5 N/ktex under which original length is measured after a minimum of 17 minutes</td>
</tr>
<tr>
<td>rope</td>
<td>a flexible line intended for loading in tension, with or without bending</td>
</tr>
<tr>
<td>performance description</td>
<td>a document that is issued by the manufacturer to describe how the rope or tether performs in the application</td>
</tr>
<tr>
<td>qualification</td>
<td>technology qualification is defined in DNV-RP-A203</td>
</tr>
<tr>
<td>S</td>
<td>used to denote the left-hand orientation of a rope or subrope strand</td>
</tr>
<tr>
<td></td>
<td>The same definition is also used for yarns.</td>
</tr>
<tr>
<td>sheathing</td>
<td>protective jacket and soil barrier (if present)</td>
</tr>
<tr>
<td>stiffness</td>
<td>stiffness, K, is the ratio of change in tension to the corresponding change in length</td>
</tr>
<tr>
<td>strain</td>
<td>strain, ( \varepsilon ), is the ratio of change-in-length, ( \Delta L ), to the original length of the rope, ( L_0 ). The strain value can also be based on another reference length for the rope, ( L_i ).</td>
</tr>
<tr>
<td>strand</td>
<td>the principal component of the rope or subrope</td>
</tr>
<tr>
<td></td>
<td>The strand is formed by an assembly of yarns which are grouped together. The strands form a rope by either a helical or braided arrangement.</td>
</tr>
<tr>
<td>stress rupture</td>
<td>breakage of a polyester, para-aramid or polyamide fibre due to prolonged application of tension</td>
</tr>
<tr>
<td>stretch</td>
<td>the change in rope length, ( \Delta L ), as result of change in tension</td>
</tr>
<tr>
<td></td>
<td>The 'change-in-length' has the unit of length in metres.</td>
</tr>
<tr>
<td>subrope</td>
<td>several subropes are assembled in a parallel bundle to form a load-bearing core</td>
</tr>
<tr>
<td></td>
<td>Guidance note:</td>
</tr>
<tr>
<td></td>
<td>Subropes are not referred to as &quot;rope&quot; in this standard, but they are indeed ropes in their own right.</td>
</tr>
<tr>
<td>system integrator</td>
<td>the party that is responsible for integration of offshore fibre ropes or tethers into a larger system such as a mooring system or deepwater deployment and recovery system</td>
</tr>
<tr>
<td></td>
<td>The system integrator is responsible for how the finalised system delivers its functions in the defined service scenarios.</td>
</tr>
<tr>
<td>technology qualification</td>
<td>technology qualification is defined in DNV-RP-A203</td>
</tr>
<tr>
<td>termination hardware</td>
<td>the (usually steel) component inserted in the rope eye to transfer the line loads from the fibre-rope segment to the connecting elements and the rest of the mooring line</td>
</tr>
<tr>
<td></td>
<td>The spool thimble is most commonly used.</td>
</tr>
<tr>
<td>test unit</td>
<td>for manufacturing of steel termination hardware, a test unit is defined as items from the same heat of steel and same heat-treatment batch</td>
</tr>
</tbody>
</table>
Chapter 1  Section 1

### Table 11  Terms (Continued)

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>tether</td>
<td>a flexible line intended for loading in tension, without bending</td>
</tr>
<tr>
<td>tex</td>
<td>a measurement unit for linear density, i.e. weight per unit length of textiles:</td>
</tr>
<tr>
<td></td>
<td>( \text{tex} = 10^{-3} \times \text{g/m} ), ( \text{d tex} = 10^{-4} \times \text{g/m} ), ( \text{k tex} = \text{g/m} ), and ( \text{M tex} = \text{kg/m} )</td>
</tr>
<tr>
<td>transport weight</td>
<td>the weight of the fibre-rope or fibre-tether segment with a water content that is</td>
</tr>
<tr>
<td></td>
<td>representative for outdoor conditions, after heavy rain and allowing excess water to drain off</td>
</tr>
<tr>
<td></td>
<td>Guidance note:</td>
</tr>
<tr>
<td></td>
<td>The spliced eyes shall be self-draining, not to accumulate any water inside the PU coating, if present.</td>
</tr>
<tr>
<td></td>
<td>---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---</td>
</tr>
<tr>
<td>Z</td>
<td>used to denote the right-hand orientation of a rope or subrope strand</td>
</tr>
<tr>
<td></td>
<td>The same definition is also used for yarns.</td>
</tr>
</tbody>
</table>
CHAPTER 2 REQUIREMENTS

SECTION 1 GENERAL

1 Introduction
This chapter describes documentation requirements and technical requirements to fibre ropes and tethers in offshore applications.

2 Marking

2.1 General
Each line shall be marked at each end with a unique identifier traceable to its certificate.

Guidance note:
Designated use and discard criteria shall be stated on label and certificate for offshore lifting slings.

2.2 Twist marker
All segments shall include a conspicuous length-ways marker in order that any undue twist can be observed. An alternative would be for at least two strands (in the braided jacket or load-bearing rope as applicable) one left hand, and one right hand to be made from durable, water-resistant, coloured yarns.

3 Transport

3.1 General
3.1.1 Offshore fibre ropes and tethers should be protected from direct sunlight.
3.1.2 If protective tarpaulin is applied to cover the rope on transportation reels then it should be of a light colour, and should be made in a canvas that also provides some protection against flame or fire.

4 Service

4.1 General
4.1.1 The lower parts of the fibre rope shall not be in contact with the sea bed during service, nor be handled or left in service in water with emulsified particles that may be transported into the load-bearing rope by the water that seeps in and out during loading.

Guidance note:
The filter on an offshore mooring fibre rope serves as protection for unloaded rope. In case of pre installation of ropes to the sea bed, it should be substantiated that the ropes will not flutter on the sea bed as result of near-bottom current.

4.1.2 The Condition Management Program and instructions for handling and installation shall be adhered to.

Guidance note:
Suggestions for how to develop the condition management program will be provided in DNV-RP-E304.

4.2 Protection cloth for spliced eyes
4.2.1 For spliced-eye terminations, protective cloth will normally be required between the eye and the termination hardware that fits through the eye. Such cloth should provide low friction and high wear resistance.
4.2.2 If a thin cover of elastomeric material is used to protect against chafing, then it shall be elastic such that the rope is not constrained from stretching or bending.

4.2.3 If a thick cover of elastomeric material is used to encapsulate the eye, it shall be applied over a tape or cloth that covers the eye and prevents direct adherence to and penetration onto the load-bearing rope. Free-flooding of the eye shall be ensured.

Guidance note:
If a fibre-tether segment is intended to be opened for later inspection, such as a service insert or test specimen, then the segment should be equipped with sufficient cloth beneath the PU coating such that the splice area can be opened as a loose carcass.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

4.2.4 The splices and eyes should have the same or better resistance to soil ingress as the fibre rope.

4.2.5 If the rope is equipped with a filter then this filter shall be continuous throughout the termination area.

4.2.6 The fibre-rope segment shall be free flooded, including in the eye regions.

4.3 Offshore mooring

4.3.1 The entire length of line shall be submerged at all times during service.

4.3.2 Mooring lines should in general not be in contact with the seabed during installation or handling. Provided the protection against soil ingress has been duly qualified, lines may be placed on the sea bed as part of the installation and handling procedure, pending retrieval and final hook up.

4.3.3 The load-bearing parts of the line shall be adequately protected from marine growth. Hard marine growth shall not occur on load-bearing yarns.

4.3.4 A mobile mooring system shall be operated with the required margins against failure, ref. DNVGL-OS-E301.

4.3.5 A long-term mooring system shall be operated with the required margins against failure, ref. DNVGL-OS-E301.

Guidance note:
For a mobile mooring system it is a requirement of DNVGL-OS-E301 that the margin to failure is minimum 3. For long-term mooring, the margin to failure shall be 5 to 8. These margins are commensurate to the margins against fatigue failure of steel components.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

4.3.6 This standard is applicable to offshore mooring fibre ropes and tethers in a regular service scenario. The following applications are considered special service that requires additional qualification activities:

— seamed contact during the installation phase
— service with physical contacts to objects such as work wires
— service in shallow water where ample marine growth occurs
— service where part of the line is above water.

4.4 Underwater deployment and recovery
Reference is made to DNV-OS-E407.

5 Condition management

5.1 General

5.1.1 The condition of offshore fibre ropes and offshore fibre tethers shall be managed during service, in order to ensure sufficient margin towards relevant failure modes.

5.1.2 Due consideration to the in-service phase shall be given in the design phase for the system, and for the offshore fibre rope as part of the system.

5.1.3 The Condition Management Program shall state how the condition of the fibre rope is managed in
practice.

**Guidance note:**
The responsibilities are stated under ‘Documentation Requirements’, below.
Reference is made to applicable DNVGL Rules for MOU with regard to mobile and long-term moorings. Further reference will be provided in DNV-RP-E304.

For materials exhibiting stress rupture, tension measurements can provide vital input for assessment of accumulated damage. (Applicable to aramid, LCAP, polyamide and polyester.)
For materials exhibiting creep failure, length measurements can provide vital input for assessment of cumulated damage. (Applicable to HMPE.)

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

5.1.4 The condition management program shall completely describe the methods and techniques for managing the condition of lines during service. Examinations and tests to be performed shall be described, together with a plan for retrieval of test material and evaluation criteria as appropriate. Instructions for ROV checking of the termination areas shall include dimensional verification of the eyes and splices, their seating and alignment on the termination hardware and checks for potential chafing.

5.1.5 The procedure for handling and installation shall contain the necessary instructions and limitations set to protect the integrity of the lines between manufacture and installed condition.

5.1.6 Restrictions with respect to seabed contact shall be conspicuously stated in the procedure for handling and installation and in the condition management program.

5.2 High tension
If it is measured or suspected that a fibre line has been subjected to a tension level exceeding 70% MBS then it should be taken out of service and re-certified or discarded.

5.3 Test material
5.3.1 Test material required to perform condition assessment may be taken when the line is not in service.

**Guidance note:**
Test material is taken by cutting off a short length and re-terminating the rope segment.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

5.3.2 For long-term moorings test material in the form of inserts can be retrieved and examined/tested if this is according to the provisions of the condition management program.

5.4 Repair
5.4.1 Methods exist for repair of offshore fibre tethers. As a general rule, the load-bearing subropes in long-term mooring systems should not be repaired. All repair methods shall be duly qualified, and the integrity of protective sheathing reinstated.

5.4.2 Any repair should only be performed by the responsible manufacturer, or his official representative.

**Guidance note:**
Information concerning fibre-rope line damage assessment and repair can be found in DNV-RP-E304, API RP 2I, ISO 18692 and CI 2001-04.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

6 Design

6.1 Load-bearing yarn
6.1.1 The load-bearing fibre yarns used in mooring ropes shall be fit for the designated service.

6.1.2 The load-bearing yarns shall be functional for the application with appropriate coating (such as marine finish for offshore mooring lines).

6.1.3 The load-bearing yarns shall be able to sustain loading within the entire design range, and have
sufficient performance margin to failure, as well as sufficient abrasion resistance and sufficiently low variability in change-in-length characteristics.

**Guidance note:**
The design range is the difference between the highest permissible tension and the lowest permissible tension in the rope. DNV Programme for Approval of Manufacturer 322 is formulated to take these aspects into account.

---end---of---g-u-i-d-a-n-c-e---n-o-t-e---

### 6.2 Rope construction

In this standard, a distinction is made between ropes that are intended to work in deflection, and tethers which are not.

**Guidance note:**
An offshore fibre tether consists of a load-bearing core of parallel elements such as subropes or parallel yarns. The tether relies on a jacket to hold the bundle of load-bearing elements together.

A rope that tolerates working under deflection may not need an external jacket, and it is the braided or helical arrangement of the strands in that single rope that accommodates deflection under tension without elements burrowing between other elements. More information on types of rope will be provided in DNVGL-RP-E305.

---end---of---g-u-i-d-a-n-c-e---n-o-t-e---

### 6.3 Terminations

#### 6.3.1 Fibre ropes

Fibre ropes are normally terminated with spliced eyes to make up the fibre-rope segment.

**Guidance note:**
For other types of fibre-rope terminations than the spliced eye an appropriate level of qualification is required in order to substantiate that the termination is safe and reliable. Reference is made to DNV-RP-A203 for principles pertaining to technology qualification.

---end---of---g-u-i-d-a-n-c-e---n-o-t-e---

#### 6.3.2 Figure 1 illustrates a typical termination for a parallel-subrope tether. The profile of the termination hardware shall be described.

![Figure 1 Fibre-tether segment fitted on spool thimble](image)

This is an illustration. The actual design of the termination is part of the design of the line as determined by the manufacturer.

#### 6.3.3 The spliced eyes should be fitted on thimbles. Thimbles act as the interface between the rope eye and the pin of the connecting element.

#### 6.3.4 Termination hardware is required to fit and support the eye and should be made of steel.

**Guidance note:**
Termination hardware made from other materials than steel should be qualified in accordance with the principles of DNV-RP-A203.

---end---of---g-u-i-d-a-n-c-e---n-o-t-e---

#### 6.3.5 If the rope or tether segment is connected directly to a custom-designed element, then that element is considered termination hardware.

#### 6.3.6 Shackles and H-links shall comply with DNVGL-OS-E302. Sockets shall comply with DNVGL-OS-E304.
SECTION 2 REQUIREMENTS TO MATERIALS

1 Load-bearing yarn

1.1 General

1.1.1 The 3-T performance characteristics of the yarn shall be sufficient for the designated service.

1.1.2 The design range of the load-bearing yarns shall be verified to be sufficient for the designated service.

Guidance note:
More information about ‘3-T performance characteristics’ and ‘design range’ is provided in DNVGL-RP-E305. They express the load-bearing capability of the yarn, and the effect of temperature.

2 Terminations hardware

2.1 General

2.1.1 Termination hardware may be cast, forged, machined or welded from plates/tubes.

2.1.2 It is the responsibility of the rope manufacturer to define the critical sections of the termination hardware, and to ensure that sufficient materials’ testing is carried out.

2.1.3 The preparation of test pieces and the procedures used for mechanical testing shall comply with the relevant requirements of DNVGL-OS-B101.

2.1.4 The tensile test values should satisfy the requirements of the specified material.

Guidance note:
Sound judgement is encouraged.

2.2 Cast and forged thimbles

2.2.1 The materials shall satisfy a Charpy V-notch impact toughness of 50 J at -20°C.

2.2.2 The mechanical tests shall be taken from sacrificial items from the actual delivery. One sacrificial item shall be taken per test unit. For each test unit, 1-off tensile tests and 3-off Charpy V-notch tests shall be performed.

Guidance note:
A test unit is defined as items from the same heat of steel and same heat-treatment batch. DNVGL-RP-E305 will provide additional notes concerning mechanical testing.

If an alternative test program is applied then this shall be rigorously substantiated.

2.2.3 The test pieces for mechanical testing shall be taken at 1/3 thickness from the surface at the critical section.

2.2.4 All items shall be 100% visually inspected and be free from burrs, rough edges, cracks, dents, cuts, and other injurious imperfections. Particular attention shall be paid to rope interface.

2.2.5 All surfaces that are in direct contact with the rope eye shall be magnetic-particle tested (MT) or Liquid Penetrant Tested (DPI) in accordance with a recognised standard.

2.3 Manufacturing from rolled plate

2.3.1 The material in plates (and tubes) shall comply with the requirements to mechanical properties of grades NV D as given in DNVGL-OS-B101.

2.3.2 Fabrication and non-destructive testing shall be in accordance with DNVGL-OS-C401. Welds shall be
2.4 Other termination elements

**2.4.1** Shackles and H-links shall comply with DNVGL-OS-E302. Sockets shall comply with DNVGL-OS-E304.

**2.4.2** The material in custom-made termination elements shall comply with DNVGL-OS-E302 and/or DNVGL-OS-C401, as appropriate.

2.5 Other materials

Other materials, such as polymers and fibre composites can be used provided they have been duly qualified based on DNV-RP-A203.
SECTION 3 PERFORMANCE CHARACTERISTICS

1 Introduction

1.1 General

1.1.1 Depending on the designated application, there may be different performance characteristics that are of importance to the selection of rope design and load-bearing material.

Guidance note:
Information on relevant failure modes and methods of testing and analysis is provided in DNVGL-RP-E305.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.1.2 Reference is made to DNV-RP-E304 for information on condition management.

2 Load-bearing yarn

2.1 General

2.1.1 The following performance characteristics shall be provided for the load-bearing yarn:
- 3-T (Tension-Time-Temperature design curve)
- Design range
- Change-in-length characteristics.

2.1.2 The rope manufacturer should establish the conditions for which this information will be needed. This will largely depend on the type of rope and application area.

3 Fibre-rope or fibre-tether segment

3.1 Tension-time-temperature performance characteristics (3-T)

3.1.1 The ability of a synthetic fibre line to carry load depends on the magnitudes and durations of tensions to be applied, the magnitudes and durations of preceding loading, and on the associated temperatures within the load-bearing material.

3.1.2 The ‘3-T’ performance characteristics shall be established by testing, whereby design curves are established for the relevant combinations of these parameters (tension, time and temperature).

Guidance note:
Recommendations are provided in DNVGL-RP-E305.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

3.2 Cyclic endurance

3.2.1 The cyclic endurance shall be verified for long-term mooring systems and ropes for deepwater deployment and recovery systems, with subsequent examinations and tests.

3.2.2 Reduced-scale cyclic endurance testing is not acceptable.

Guidance note:
On certain conditions a larger line can cover the cyclic-endurance test requirement of a smaller line. It is recommended to perform testing on a sample that covers more than just one delivery of the same yarn material and type of rope and splices.

It is not possible to cover the effects of interaction in the rope eye if a scaled specimen is used, even if subropes in a mooring tether are not scaled.

The requirement to cyclic endurance testing of line does not apply to mobile moorings.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

3.2.3 The resistance of the splices against slipping out in the full rope shall be documented as part of the cyclic endurance test.
3.3 Splice integrity

3.3.1 The splice design shall be self-locking. The number of cycles to lock the splices shall be stated in the rope performance description and verified by testing.

Guidance note:
The splice is self-locking when the force vs. pin-pin displacement curve has a clearly asymptotic behaviour towards a specific rope length at peak tension. Recommendations for testing are provided in DNVGL-RP-E305.

---end---of---guidance---note---

3.4 Change-in-length characteristics

3.4.1 The change-in-length characteristics of the line shall be sufficiently described for the needs of the system integrator to calculate system behaviour. Thus, the testing shall be specified according to the measurement results that are needed in the system analyses.

3.4.2 The testing shall reflect the actual application of the system, including accommodation of lifetime extremes.

Guidance note:
The system integrator can base the testing requirements on generic loading scenarios, such as those given by ISO 18692 or API RP 2SM for offshore moorings, provided the results yielded are acceptable to perform the required change-in-length analyses of the rope.

---end---of---guidance---note---

3.5 Torque and twist characteristics

3.5.1 The torque and twist characteristics are defined as the resulting torque and/or twist that the line exerts when loaded.

3.5.2 The torque and twist characteristics shall be stated in the performance description and verified by testing.

3.5.3 Fibre ropes and tethers that are inherently torque neutral need not be tested if they are to be used with torque-neutral components only.

3.6 Breaking strength

3.6.1 The minimum breaking strength (MBS) of the line shall be verified by testing. In the rope performance description, the MBS should be stated in kN and in N/tex relating to the nominal load-bearing linear density.

3.6.2 Break testing is important in order to verify that the process for terminating the ropes is repeatable and reliable, and to verify the performance of the termination hardware and the termination-to-hardware integration.

3.6.3 The lowest result should meet or exceed the required MBS.

Guidance note:
Break tests serve as coarse verification of the strength of the fibre rope when tested under given conditions using test samples of limited length.

The breaking strength that is obtained in testing is a result of the tension-time-temperature (3-T) performance characteristics; hence it will vary depending on the rate of loading in the final parts of the test, and the temperature of the load-bearing yarns.

The use of break strength as the governing performance characteristic for the rope is discouraged. The 3-T and CIL performance are more important than MBS. Under this standard, the minimum breaking strength is used as a casual reference for the rope.

If the lowest result fails to meet an MBS requirement it should be observed that increasing the nominal load-bearing linear density can have adverse effects such as increased fatigue exposure of steel components and a less compliant rope. Rope bulkiness is usually no advantage, and in a DDRS system the tendency to generate heat will increase.

If the lowest result is significantly lower than the other results, leading to suspicion that something was wrong with the sample, then it can be disregarded provided the manufacturer produces a technical report with detailed analysis and explanation of the cause of the low result, and demonstrates the measures to be implemented to prevent the same error to occur during production of the delivery.

Sound judgement is encouraged.
3.7 Resistance to soil ingress of mooring lines

3.7.1 The resistance to soil ingress shall be stated in the rope performance description and verified by testing and/or qualification based on DNV-RP-A203.

3.7.2 For lines subject to tension prior to sea-bed contact, the soil-ingress resistance test shall be performed on a specimen that has been stretched at a similar or higher tension level.

3.7.3 The resistance of the termination areas shall be documented in the rope performance description. Substantiating documentation should be provided in the rope design description, the manufacturing description and the test results from stretching of fibre-rope segments, if performed.

Guidance note:
The soil test samples can be taken from the free length, whilst the resistance of the termination areas can be covered by documentation that it is ‘equal to or better’ than the free length. ‘Equal to or better’ usually entails that the filter is continuous throughout the termination areas, and that no localised cracks may form if the rope is stretched prior to seabed exposure.

---end---of---guidance---note---

3.8 Hysteresis heating

It shall be verified that the maximum temperature inside the offshore fibre rope due to hysteresis heating and other heating contributions does not exceed the design temperature.

Guidance note:
For submersed service as offshore mooring any hysteresis heating is normally not expected, yet the requirement to free-flooding must be observed for all parts of the rope including terminations.

Other heat sources than hysteresis heating can be internal and external friction; and high ambient temperature may impede heat dissipation.

---end---of---guidance---note---

3.9 Low-tension durability

For aramid yarn materials, low-tension durability shall be considered as appropriate.

4 Termination hardware

4.1 General

4.1.1 The requirements to material properties of the termination hardware are given above.

4.1.2 The strength, ductility and toughness of the termination hardware material should be such that it can withstand the actual break loading of the offshore fibre rope or tether.
CHAPTER 2  SECTION 4  DESIGN VERIFICATION

1  Documentation requirements

1.1  General

1.1.1 This section covers documentation requirements.

1.1.2 The design verification shall confirm that the design of the line satisfies the system integrator specification and the requirements of this standard.

1.1.3 The work consists of review of specifications, drawings, calculations and other data supplied by the system integrator and the manufacturer, documenting the strength and serviceability of the actual line including the termination hardware. An overview of the required documentation is listed below.

1.1.4 A design verification carried out on an offshore fibre rope or offshore fibre tether is only valid for that specific line.

1.1.5 For long-term moorings, the design verification is only valid for the designated location.

1.1.6 The linear density of yarns should be stated in dtex.

1.1.7 The nominal load-bearing linear density of strands and subropes should be stated in ktex.

1.1.8 The nominal load-bearing linear density of ropes should be stated in ktex or Mtex.

1.2  System integrator

1.2.1 This section provides the requirements to documentation from the system integrator for the purpose of design verification of the offshore fibre ropes or tethers.

1.2.2 The system integrator shall provide the rope manufacturer with a rope specification.

1.2.3 The rope specification shall contain all information about required 3-T capacity, characteristic line tension in operation, required torque and twist characteristics, required design range, design temperature, handling procedure, length of segments etc. that is required for the rope manufacturer to propose and make the right rope for the application.

1.2.4 The system integrator is responsible for establishing the condition management program, which shall be submitted to the rope manufacturer as part of the enquiry.

Guidance note:
The system integrator is the company that is responsible for the system design engineering, and the integration of the fibre ropes with the other elements of the system.

System Integrator and Rope Manufacturer may well cooperate in establishing the best possible condition management program.

1.2.5 In addition, the system integrator specification for long-term moorings shall as a minimum include the following

— requirements to length of lines as-new and during the service life
— service requirements and operational boundaries for the finalised mooring system
— design life
— highest and lowest occurring sea-water temperature
— minimum bending diameter during transport and installation
— evaluation of sea-bed particles (e.g. sand and mud) experienced by the fibre rope or tether during installation.

Guidance note:
Service requirements and operational boundaries comprise installation sequence, pre-tension, loading scenario including the maximal occurring cyclic loading.

If any of the components in the mooring line are not torque neutral, then an analysis of the torque / twist interaction shall be submitted. Documentation in the form of analyses and/or test results should be submitted to demonstrate no adverse effects.
Mixing torque-generating steel-wire rope with torque neutral fibre rope is mainly a concern for the cyclic endurance of the steel-wire rope. As a general rule, mooring chain should not be subjected to excessive torque in operation. Swivels should be used with caution.

---end---of---guidance---note---

1.2.6 In addition, the system integrator specification for DDRS rope shall as a minimum include the following:

- Interface with MLA including the rope path and storage.
- Rope design temperature at peak performance of DDRS.
- Performance margin requirements when running on winch and rope path.

1.3 Rope manufacturer

1.3.1 This section provides the requirements to documentation from the rope manufacturer for the purpose of design verification of the offshore fibre ropes or tethers.

1.3.2 The documentation from the manufacturer shall as a minimum contain:

- design description
- performance description
- testing specification
- procedure for handling and installation
- description of material for the fibre rope sheathing, consisting of filter and jacket
- description of load-bearing yarns
- documentation of the materials for spliced-eye protection
- documentation of the termination hardware.

1.3.3 The design description shall include; type of fibre rope construction, type of termination, nominal load-bearing linear density, detailed design drawings, and weight of the line in sea water, performance characteristics, and change-in-length characteristics.

1.3.4 The rope manufacturer shall issue a Performance Description, which details the performance characteristics of the offshore fibre rope or tether.

1.3.5 The rope performance description shall include detailed information about how the line performs in the application, such as change-in-length and torque responses, and changes in load sharing when it is twisted and bent. See section "Performance Characteristics" above.

Guidance note:
Recommendations are provided in DNVGL-RP-E305.

---end---of---guidance---note---

1.3.6 The rope manufacturer should describe the following for the load-bearing yarn:

- manufacturer and manufacturing plant
- yarn designation
- nominal and actual range of linear density
- 3-T performance characteristics
- design range
- change-in-length performance
- yarn breaking strength
- wet yarn-on-yarn abrasive performance
- marine finish designation
- seawater hydrolysis resistance.

Guidance note:
More information about the 3-T performance characteristics is provided in DNVGL-RP-E305.
The design range stated in the load-bearing yarn product certificate shall be verified to be within the intended operations of the system.

1.3.7 The testing specification shall be specific to the tests that shall be performed. It shall describe all activities and tasks, even if these are entirely based on or taken from existing standards. The testing specification shall not contain any references.

**Guidance note:**
The test machine operator should be allowed to devote time and attention to performing tests that are unambiguously described. It should not be put upon the test machine operator to interpret standards on behalf of the system integrator. Nor is that in the role of the independent verifier at commencement of testing.

1.3.8 The sheathing, if applicable for the type of offshore fibre rope, consists of the following:

- the rope jacket
- the filter, if applicable.

1.3.9 The permeability of the sheathing with respect to water and solids shall be stated in the rope performance description.

1.3.10 In order to prohibit marine growth in mooring lines the jacket sheathing shall be sufficiently dense to protect the rope interior from sunlight. It shall protect the load-bearing yarns against penetration of hard marine growth.

1.3.11 The effect on the sheathing of UV light, of intensity corresponding to that experienced during transport, storage and operation, and after a time corresponding to the design life, shall be stated in the fibre-rope description.

1.3.12 The description of the sheathing shall as a minimum include the following information

- manufacturer and manufacturing plant
- designation
- sheathing weight/thickness
- permeability to water
- permeability to sunlight
- UV resistance
- seawater hydrolysis resistance
- resistance to chemicals.

1.3.13 Documentation of the termination hardware shall include drawings specifying material, geometry, location of critical section from where mechanical test pieces will be taken, method of manufacture. A structural-strength calculation report should be submitted if applicable.

1.3.14 The weight of the fibre rope in sea water should be documented by calculation and stated in kg/m, together with the submerged weight of the terminations and termination hardware.

1.3.15 The transport weight of each fibre-rope segment and the termination hardware should be stated.

1.3.16 The spliced eyes shall be self-draining, not to accumulate any water inside the PU coating, if present.

1.4 Yarn manufacturers

The documentation requirements to the manufacturer of the load-bearing yarn are the same as the documentation requirements of DNV Programme for Approval of Manufacturer 322, and as stated in this standard for testing of deliveries.

1.5 Termination hardware manufacturers

The manufacturer of the termination hardware shall submit documentation to the rope manufacturer on
material, processing, mechanical properties, dimensions, fabrication and tolerances of the finalised products.
SECTION 5 TESTING OF DELIVERIES

1 Introduction

1.1 General

1.1.1 This section covers the required extent of testing when offshore fibre ropes and tethers are manufactured for delivery.

1.1.2 All methods of testing shall be described in the testing specification which is part of the documentation that shall be provided by the rope manufacturer.

Guidance note:
Recommendations for methods of testing are provided in DNVGL-RP-E305.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2 Testing of load-bearing yarn

2.1 General

2.1.1 The following applies to testing carried out during manufacturing of the yarns for the actual delivery.

2.1.2 In order that test results obtained are reproducible and give reliable information about the material, the sampling must be true and representative. The sampling procedure should be designed to take account of the known sources of variability such as the variation between spindles, the variation along the length of the bobbin, etc. Sampling may be based on ASTM D2258.

2.1.3 The manufacturer should carry out testing according to Table 1 as a minimum and keep records of all testing.

2.1.4 The test methods, number and selection of parallels, acceptance criteria, and minimum frequency of control for each parameter for quality control are given in Table 1.

Table 1 Requirements to tests at yarn manufacturer for the delivery

<table>
<thead>
<tr>
<th>Control on</th>
<th>Reference 1)</th>
<th>Acceptance Criteria</th>
<th>Minimum level of verification</th>
<th>Frequency of control</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-T testing 2)</td>
<td>Specified by the manufacturer</td>
<td>Specified by the manufacturer</td>
<td>Results documented in production log</td>
<td>Specified by the manufacturer</td>
</tr>
<tr>
<td>Change-in-length</td>
<td>Specified by the client</td>
<td>N/A</td>
<td>Results documented in production log</td>
<td>Specified by the manufacturer</td>
</tr>
<tr>
<td>Chemical composition</td>
<td>Specified by the manufacturer</td>
<td>Specified by the manufacturer</td>
<td>Results documented in production log</td>
<td>Specified by the manufacturer</td>
</tr>
<tr>
<td>Glass-rubber transition</td>
<td>Specified by the manufacturer</td>
<td>Manufacturer’s specified value</td>
<td>Results documented in production log</td>
<td>Specified by the manufacturer</td>
</tr>
<tr>
<td>Linear density</td>
<td>ASTM D885M</td>
<td>Mean ± 2 st.dev within manuf. Nominal value ± 5%</td>
<td>Results documented in production log</td>
<td>Each day</td>
</tr>
<tr>
<td>Marine finish</td>
<td>Specified by the manufacturer</td>
<td>Manufacturer’s specified value</td>
<td>Results documented in production log</td>
<td>Each day</td>
</tr>
<tr>
<td>Moisture content</td>
<td>ISO 3344</td>
<td>Manufacturer’s specified value</td>
<td>Results documented in production log</td>
<td>Specified by the manufacturer</td>
</tr>
<tr>
<td>Tension vs. strain</td>
<td>ASTM D885M</td>
<td>Manufacturer’s specified value, not more than ± 5% of nominal value</td>
<td>Results documented in production log</td>
<td>Each day</td>
</tr>
<tr>
<td>Visual</td>
<td>Specified by the manufacturer</td>
<td>Specified by the manufacturer</td>
<td>Results documented in production log</td>
<td>Continuous during production</td>
</tr>
<tr>
<td>Yarn-on-yarn abrasion</td>
<td>CI 1503</td>
<td>Specified by the manufacturer</td>
<td>Results documented in production log</td>
<td>According to test standard</td>
</tr>
</tbody>
</table>

1) Or other established reference.
2) Recommendations will be provided in DNVGL-RP-E305.
## 3 Testing of rope and tether

### 3.1 General

**3.1.1** Provided production settings are not changed, the samples for testing can be produced and tested before production of the delivery.

**3.1.2** It is the rope manufacturer’s responsibility to take sufficient number of rope samples in order to complete the necessary tests to document the fibre-rope properties. This includes necessary spare length if other testing should be required later.

**3.1.3** Required number of specimens for testing is presented in the following, for the various application areas.

**3.1.4** The same set of termination hardware may be used for all tests that require specimens of the actual line to be tested.

### 3.2 Offshore mooring

**3.2.1** Requirements to test specimens are specified in the tables below.

#### Table 2 Requirements to test specimens for mobile mooring

<table>
<thead>
<tr>
<th>Type of test</th>
<th>Number of test specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-T performance characteristics</td>
<td>To be determined on case-by-case basis. Subropes should be used if relevant.</td>
</tr>
<tr>
<td>Splice integrity</td>
<td>Minimum 3 parallels. Subropes should be used if relevant.</td>
</tr>
<tr>
<td>Change-in-length performance</td>
<td>Minimum 3 parallels for each test sequence. Subropes should be used if relevant.</td>
</tr>
<tr>
<td>Breaking strength</td>
<td>5 subropes and 3 specimens of actual line.</td>
</tr>
<tr>
<td>Torque and twist</td>
<td>Minimum 1 fibre rope, if applicable.</td>
</tr>
<tr>
<td>Soil ingress resistance</td>
<td>Minimum 1 fibre rope, if applicable.</td>
</tr>
</tbody>
</table>

**Guidance note:**
For the 3-T performance characteristics, recommendations are provided in DNVGL-RP-E305.

‘Used’ refers to samples taken from the sample subjected to the cyclic endurance test.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

**3.2.2** The testing should be performed identically on each specimen such that variability can be assessed. For helical subrope constructions, both S and Z shall be tested to a total number as given in the table.

**Guidance note:**
The required number of tests is the combined number of tests of both S and Z specimens.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---
3.3 Testing of maximum temperature due to hysteresis heating in mooring lines

3.3.1 If deemed necessary, the maximum temperature shall be measured during cyclic endurance testing.

3.3.2 The measuring method shall ensure that it is the internal temperature of the fibre at critical location, and not that of the surrounding air or water, which is measured.

**Guidance note:**
If, during the cyclic endurance test of a fibre rope or tether, the measured temperature is considered to be higher than can be expected under actual load conditions, e.g. due to application of a broader than actual load range, then the loading regime should be modified during the temperature measurements to avoid over conservatism.

---end-of-guidance-note---

3.4 Deepwater deployment and recovery

3.4.1 The requirements to testing of fibre ropes for DDRS shall be established on a case-by-case basis in order to suit the assurance argument. The requirements to testing of fibre ropes shall thus be system specific and are set by the integrated system requirements. Reference is made to DNV-OS-E407.

3.4.2 The definition of rope tests will depend on the qualification strategy for the system.

4 Test methods

4.1 General

4.1.1 All tests shall be described in the testing specification, which is part of the rope manufacturer documentation.

4.1.2 In addition to the recommendations that are provided in DNVGL-RP-E305, recommendations concerning test methods can be found in API RP 2SM and ISO18692, and in other standards, recommended practices, or guidelines and company specifications.

4.1.3 The tension levels, sequences of loading and other information derived from the system analysis as needed to define the performance testing shall be submitted to the manufacturer in the rope specification. Due to the dependence of rope length on actual loading, the testing specification should reflect the actual loading scenario as closely as possible.

4.1.4 All test specimens should be pre-soaked by complete immersion in fresh water prior to testing.

4.1.5 In case of polyamide load-bearing yarn, soaking time and handling shall be in accordance with OCIMF.

**Guidance note:**
Fibre ropes for long-term offshore moorings shall be tested based on the requirements derived from the design analysis. The testing specification shall reflect the actual loading scenario for the mooring system. Since a Mobile Mooring system is normally used in different locations and service scenarios, with ample possibilities for line-length adjustment, it can be sufficient to perform change-in-length testing based on API RP 2SM or ISO 18692.

---end-of-guidance-note---

4.2 Termination hardware

4.2.1 One set of the termination hardware shall be tested as part of specimens of the actual line during break testing and cyclic endurance testing.

**Guidance note:**
The same set of hardware can be used for both break testing and endurance testing. Hence, a minimum of two thimbles will be needed with pinholes adapted to fit the test machine. The test thimbles should be made as part of the actual delivery.

---end-of-guidance-note---

4.2.2 If termination hardware produced as part of the supply is not available at the time of break testing, then the strength of the termination hardware can be demonstrated through non-linear FEM analysis.
It is the responsibility of the rope manufacturer to define the distribution of loading on the termination hardware.

**Guidance note:**
Flange bending should be included in the load case.
If samples of the actual line are break tested without termination hardware from the actual delivery, then the interface to the fibre rope eye shall be identical to that of the termination hardware.
The cyclic endurance testing should be performed using termination hardware from the actual delivery. FEM analysis is only applicable to the strength of the thimbles.

---end of guidance note---

### 4.3 Materials testing of termination hardware

#### 4.3.1 Requirements to materials testing and non-destructive examination as part of manufacturing are given in Section 'Requirements to Materials' of this standard.

**Guidance note:**
Recommendations are provided in DNVGL-RP-E305.

---end of guidance note---

#### 4.3.2 Shackles and H-links shall comply with DNVGL-OS-E302. Sockets shall comply with DNVGL-OS-E304.
CHAPTER 3 CLASSIFICATION AND CERTIFICATION

SECTION 1 CLASSIFICATION AND CERTIFICATION

1 Classification

1.1 Introduction

1.1.1 As well as representing DNV GL’s recommendations on safe engineering practice for general use by the offshore industry, the offshore standards also provide the technical basis for DNV GL classification, certification and verification services.

1.1.2 A complete description of principles, procedures, applicable class notations and technical basis for offshore classification is given by the DNV GL Rules for classification of offshore Units, see Table 1.

Table 1 DNV GL Rules - Offshore units

<table>
<thead>
<tr>
<th>No.</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>DNVGL-RU-OU-0101</td>
<td>Offshore drilling and support units</td>
</tr>
<tr>
<td>DNVGL-RU-OU-0102</td>
<td>Floating production, storage and loading units</td>
</tr>
<tr>
<td>DNVGL-RU-OU-0103</td>
<td>Floating LNG/LPG production, storage and loading units</td>
</tr>
<tr>
<td>DNVGL-RU-OU-0104</td>
<td>Self elevating units</td>
</tr>
</tbody>
</table>

2 Certification

2.1 General
The following requirements will be applied in conjunction with DNV certification according to this standard.

2.2 Main elements in certification
The main elements in certification of offshore fibre ropes and offshore fibre tethers are Approval of Manufacturer, design verification and fabrication survey.

2.3 Approval of manufacturer

2.3.1 Load-bearing yarn, fibre-rope or tether segments and termination hardware shall be manufactured at works which have been approved by DNV GL.

Guidance note:
Approved manufacturers are published on www.dnvgl.com.
The approval of yarn converters is covered by the approval of manufacturers for load-bearing yarns.

2.3.2 In order to be approved, the manufacturer shall demonstrate and submit documentation to the effect that the necessary manufacturing, testing and inspection facilities and procedures are available and are supervised by qualified personnel. The manufacturer shall also carry out a test programme and submit the results.

2.3.3 Detailed programmes for approval are given in DNV Programmes for Approval of Manufacturers 321 for rope manufacturers and No. 322 for yarn manufacturers.

2.4 Deviations and test waivers

2.4.1 If a manufacturer or system integrator wish to deviate from the requirements of this Offshore Standard, or any reference standard, then a substantiated request for waiver of test or deviation shall be submitted for approval by DNV GL. Any such request should be included in the Request for Certification.

2.4.2 Any deviations, exceptions and modifications to referenced codes and standards shall be documented and agreed between system integrator, manufacturer and DNV GL.
Design verification covers review of specifications and documentation listed in Ch. 2 and issuance of design verification report.

Survey during manufacture

2.6.1 Fabrication survey shall be based on attending tests and inspections, monitoring manufacturing, and review of records.

2.6.2 Follow-up and witness of the production shall be based on the manufacturing description and the inspection and test plan.

Certification of yarns

3.1 Load-bearing yarns

3.1.1 Load-bearing yarns shall be certified by DNV GL. At least one load-bearing yarn certificate will be issued for each delivery of offshore fibre ropes and tethers.

Guidance note:
Deliveries to different clients will not be covered by the same certificate, even if the load-bearing yarns are from the same production. If, for example, the same production of load-bearing yarns is split between two clients, then two certificates will be issued for the load-bearing yarns.

3.1.2 Certification of yarn consists of monitoring and witnessing of testing according to an inspection and test plan (ITP).

3.1.3 Lots for making the yarn shall be delivered with the manufacturers own certificate or a works certificate.

3.1.4 The following particulars will be listed in the certificate:

- purchaser’s name, order number
- manufacturers name
- description of products
- grade of yarn, delivery condition (coating etc.)
- identification marking
- test results.

The types of testing for production deliveries are given in Ch. 2. The extent of survey and testing should be taken as given by the Approval of Manufacturer documentation.

3.2 Non-load-bearing components

3.2.1 Sheathing materials should be ordered with 2.2 certificates, as defined in EN 10204.

3.2.2 In case of a custom-designed jacket for increased cut resistance, materials shall be ordered with 3.2 certificates.

Certification of termination hardware

4.1 General

4.1.1 Thimbles shall be certified by DNV GL, based on the requirements of this standard.

4.1.2 Other termination hardware elements shall be certified by DNV GL according to the appropriate standard.

4.1.3 One DNV GL certificate will normally be issued for the entire delivery. For certain applications such
as mobile moorings it may be desirable to issue one certificate per termination hardware element.

5 Certification of lines

5.1 Introduction

5.1.1 This section describes the work process that shall take place when lines are certified according to the requirements of this standard. It is attempted to give this chapter a chronological order such that the prerequisites for certain steps or milestones may be readily determined. The requirements are found in Ch.2.

5.1.2 Offshore fibre ropes and tethers shall be certified by DNV GL. Certification consists of survey according to ITP. The scope of survey shall as a minimum include intervention points as listed in App.A.

5.1.3 One DNV GL certificate will normally be issued for the entire delivery. For certain applications such as mobile moorings it may be desirable to issue one certificate per line.

5.1.4 Following particulars will be listed in the certificate:

- purchasers name, order number and vessel identification, were known
- manufacturers name
- nominal load-bearing linear density
- description of products and dimensions (length and nominal diameter)
- construction
- identification marking
- reference to yarn certificate
- reference to thimble certificate(s)
- MBS
- A reference to repair procedure (if applicable).

6 Special service

6.1 General

6.1.1 For applications which are considered as special service the line shall be fully qualified according to the principles of DNV-RP-A203, subject to approval by DNV GL.

6.1.2 For mooring lines, reference is made to Ch.2 Sec.2 of this document for special service categories.

6.2 Sea-bed contact
In case of special service requirements such as sea-bed contact qualification activities shall be carried out based on DNV-RP-A203, subject to approval by DNV GL.

6.3 External contact

6.3.1 Mooring lines intended for service with contact against external objects (such as work wires) shall be fully qualified for the designated service based on the principles of DNV-RP-A203.

6.3.2 Full qualification entails substantiating that all failure modes are managed.

7 Re-certification of offshore fibre ropes and tethers

7.1 General

7.1.1 Used lines may be re-certified for continued or prolonged service according to the provisions of this standard.

7.1.2 Cases which may warrant re-certification can be:
— rope or tether design life has expired and the service period of the system shall be extended
— the system has seen excessive loads compared to the design premise
— the line has not been previously certified by DNV
— the rope has been damaged and needs repair.

7.1.3 The requirements for re-certification will be determined by DNV GL’s Responsible approval centre on a case-by-case basis.

Guidance note:
If a rope is re-certified either in connection with repair or after expiry of previous certificate, an endorsement of the previous certificate will be issued. The endorsement will refer to the certificate number. The endorsement will be issued by the DNV GL surveyor witnessing the repair. Depending on the extent of the repair, design verification will be required. The history of the rope will be stated to the extent possible.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

7.1.4 The certificate of a rope that is repaired by cutting off the shortest section and performing re-termination according to approved procedure for production will be endorsed without design verification of the repair.

7.1.5 The certificate of a rope that is repaired according to an approved repair procedure that is part of the scope of the manufacturer approval by DNV GL may be endorsed without design verification of the repair.

7.1.6 The repair work will be subject to DNV GL survey.
SECTION 2 WORK PROCESS FOR CERTIFICATION OF LINES

1 General

1.1 Introduction

1.1.1 In the following, the work process is described. The process consists of the following main steps in chronological order:

— request for certification
— pre-production meeting
— submittal of documentation for approval
— design verification
— production and survey
— issuance of certification documents.

1.2 Request for certification

1.2.1 The request for certification should be sent to DNV GL by e-mail. The following information should be included:

General:

— manufacturer name, plant location and reference to manufacturer-approval certificate
— production and delivery schedules for fibre-rope segments and termination hardware
— testing facilities, location and foreseen testing schedule
— type of application
— scope of delivery
— any requests for deviations or test waivers, fully documented
— dimension, breaking strength of the line, including type of fibre and rope or tether construction.

Additional information for long term mooring systems:

— in-service condition assessment scheme
— key results from analysis in order to decide the load levels to be used in the certification test program and determine the rope length in production.

1.3 Pre-production meeting

1.3.1 A pre-production meeting shall be held at the manufacturer’s premises prior to start of the certification process.

1.3.2 The meeting shall include representatives from the following organisations:

— manufacturer of the fibre ropes
— DNV GL surveyor from local survey station appointed to follow up production and testing
— representative from DNV GL’s Responsible approval centre in case of special service requirements requiring additional qualification activities
— representative from testing facility if the tests are not carried out by the manufacturer or by DNV GL.

1.3.3 The presentation made by the manufacturer shall include:

— scope of work
— outline and description of the components to be produced
— content and requirements of purchase orders/specifications
— testing facilities
— any requests for deviations or test waivers
— any elements not directly covered by this standard
— manufacturer’s description/specification regarding production, terminations and testing.

1.3.4 The presentation made by DNV GL will include:
— presentation of DNVGL-OS-E303 (this standard)
— outline and explanation of specific requirements regarding class and certification
— scope of design verification and survey to be carried out by DNV:
  — status of documentation submitted to DNV
  — status approval of rope manufacturer and sub suppliers
  — survey during fabrication of fibre-rope segments and termination hardware
  — certification of the termination hardware (type of certificate it shall be ordered with, and requirements to materials and testing)
  — witnessing during testing.
— final documentation requirements:
  — content
  — issue and distribution
  — review of final documentation.

1.3.5 Minutes of Meeting from the pre-production meeting should be issued by the QA responsible of the manufacturer and distributed to the involved parties.

2 Design verification

2.1 General

2.1.1 The design verification will be carried out based on the required documentation which shall be submitted by this stage in the work process.

2.1.2 The documentation requirements and the responsibilities of the system integrator and the manufacturer are summarised in Ch.2. Approved design documentation and procedures will be listed in the Design Verification Report (DVR).

3 Design verification report

DNV GL will issue a Design Verification report (DVR) for the lines. The DVR will state:
— documents which have been reviewed
— complying standards
— assumptions
— conditions and limitations
— a list of all documents from the client/manufacturer will be included together with reference correspondence; any comments which are to be taken into account.

4 Start-up of production

The production of the fibre-rope segments can commence when DNV’s Responsible Approval Centre has issued the Design Verification Report.

This will be notified in an e-mail to the manufacturer from the DNV GL surveyor.
5 Survey during production and testing

5.1 Scope of survey

5.1.1 Check certificates for load-bearing yarns.

5.1.2 Check certificates for yarns and fabrics to be applied in the sheathing process.

5.1.3 Prior to start of testing, the attending surveyor and the responsible test engineer should review the approved testing specification together.

5.1.4 Number of rope tests to be witnessed has to be decided by the attending DNV GL surveyor based on experience with the product and the testing laboratory. For testing carried out by DNV, the survey will be performed by the responsible test engineer.

5.1.5 Witness that the production is carried out in accordance with the manufacturing specification and associated QA plans regarding the production of subropes, fibre ropes, terminations and sheathing.

5.1.6 Scope of survey at the rope manufacturer can be found in App.A of this standard.

6 Testing

6.1 General

6.1.1 The testing shall be carried out according to the provisions set forth in the testing specification.

6.1.2 The testing specification for all tests and reporting is subject to approval by DNV GL.

6.1.3 Subject to documentation and approval by DNV, fibre rope or fibre tether specimen(s) may be used for change-in-length testing for mobile moorings, instead of subropes.

Guidance note:
This depends on the measurement accuracy which is required by the system integrator for the mooring analysis.

6.1.4 If cyclic endurance testing and subsequent examinations according to approved procedure of an equal-size or larger, but otherwise identical, line has been carried out before, then the test can be waved – subject to a substantiated waiver request and approval by DNV GL.

Guidance note:
The same specimen can be used for measuring different properties.
In offshore mooring, the change-in-length performance is paramount to the system design. Thus, design-specific specification should be made for each mooring system. Notwithstanding this, universal test results for stiffness and change in length can be accepted. Examples on change-in-length tests can be found in API RP 2SM, ISO 18692 or in CI 1500. Examples of torque-measurement testing and soil-ingress resistance testing can be found in ISO 18692.

7 Certificates

7.1 Certificates for load-bearing yarns
The load-bearing yarn for the fibre ropes shall be ordered with DNV GL certification at the works with reference to this standard.

7.2 Certificates for termination hardware
Termination hardware shall be ordered with DNV GL certification at the works, with reference to this, or the appropriate other, standard as detailed in Ch.2.

7.3 Certificates for offshore fibre ropes and offshore fibre tethers
Certificates for Offshore Fibre Ropes and Offshore Fibre Tethers will be issued with reference to this Standard.
**APPENDIX A  SCOPE OF SURVEY AT ROPE MANUFACTURER**

Surveyor shall have access to the manufacture at any time of production.

An inspection and test plan shall be issued by the manufacturer. The ITP shall be reviewed and approved by the surveyor prior to start of production.

The DNV GL intervention points shall as a minimum include following:

### Table 1  Survey scope

<table>
<thead>
<tr>
<th>Activity</th>
<th>Ref. in OS</th>
<th>DNV GL role</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Pre-production meeting**      | Ch.3 Sec.2 | H           | Scope of delivery Schedule/ITP  
Rope manufacturer, AoM status  
Yarn type/manufacturer, AoM status  
Termination hardware, AoM status  
Testing facilities  
Design documentation status |
| **Materials**                   | Ch.2 Sec.2 | M/R         | Procurement of materials (yarns, filters, sheathing)  
-recipe of goods:  
Check certificates and traceability for load-bearing yarns  
Check certificates and traceability of termination hardware  
Certificates and traceability of non-load-bearing yarns, filters, etc. |
| **Manufacturing of subropes**   |            | H(W)/M      | Witness start of production then monitoring  
-procedure compliance  
Witness that the production is carried out in accordance with the manufacturing specification and associated QA plans regarding the production of subropes.  
Hold point on first subrope if next rope is manufactured with same setup.  
Witness point on remaining subropes. |
| **Braiding of rope**            |            | H(W)/M      | Witness start of production. Set up of register plates, set up of machines. Then monitoring  
Procedure compliance  
Witness that the production is carried out in accordance with the manufacturing specification and associated QA plans regarding the production of ropes.  
Hold point on first rope if next rope is manufactured with same setup.  
Witness point on remaining ropes. |
| **Eye splicing/ Coating**       |            | H/W         | Hold point on first splice. For each step in the production process for the soft eye the DNV GL surveyor will witness compliance to manufacturing description and rope design description,  
For remaining terminations witnessing will be carried out.  
Procedure compliance. Including application of PU coating. |
| **Testing of rope**             | Ch.2 Sec.4 | H           | Survey of all tests on the subropes and the full ropes. Prior to start of testing, the attending DNV GL surveyor and the responsible test engineer should review the approved testing specification together.  
Visual inspection of the finished line with hardware fitted, marking, splices, how thimbles are sitting and ease of assembly.  
Testing shall be in accordance with approved testing specification |
| **Final inspection**            |            | H           | Visual inspection of the finished fibre rope.  
Inspection on transportation/packing of the rope, shall be within specification for handling and installlation. Marking and packing in accordance to approved procedure.  
Check identification marking of ropes, thimbles etc.  
Visual inspection of the rope, no cuts and abrasion, eyes thimbles, chafe protection |
| **Records (Data book)**         | R          |             | Production and test reports  
Complete design documentation |
| **Issuance of certificate**     | H          |             | |

**Definitions:**
**Hold point (H):** A point where DNV GL shall be present for survey. Advance notification to DNV GL shall be given in writing or any other agreed system of notification. Work shall not proceed beyond a hold point without DNV GL present or, in exceptional cases where presence is waved, without first obtaining a written authorisation from DNV GL.

**Witness point (W):** A point where DNV GL may be present for survey, at their discretion. Advance notification to DNV GL shall be given in writing or any other agreed system of notification. Work may proceed beyond a witness point with or without DNV GL present.

**Monitoring (M):** Intermittent survey of any stage of the work in progress including, but not limited to, checking compliance with procedures/instructions for manufacture, testing and inspection, observing workmanship, traceability, etc.

**Review (R):** Examination of records of activities performed or results achieved.
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