Offshore Fibre Ropes

FEBRUARY 2013

The electronic pdf version of this document found through http://www.dnv.com is the officially binding version
FOREWORD

DNV is a global provider of knowledge for managing risk. Today, safe and responsible business conduct is both a license to operate and a competitive advantage. Our core competence is to identify, assess, and advise on risk management. From our leading position in certification, classification, verification, and training, we develop and apply standards and best practices. This helps our customers safely and responsibly improve their business performance. DNV is an independent organisation with dedicated risk professionals in more than 100 countries, with the purpose of safeguarding life, property and the environment.

DNV service documents consist of among others the following types of documents:
— Service Specifications. Procedural requirements.
— Standards. Technical requirements.

The Standards and Recommended Practices are offered within the following areas:
A) Qualification, Quality and Safety Methodology
B) Materials Technology
C) Structures
D) Systems
E) Special Facilities
F) Pipelines and Risers
G) Asset Operation
H) Marine Operations
J) Cleaner Energy
O) Subsea Systems
U) Unconventional Oil & Gas
CHANGES

General
This document supersedes DNV-OS-E303, October 2010.

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.

Main changes
The document has been revised to serve as a reference standard of the new DNV-OS-E407 'Underwater Deployment and Recovery Systems'.

The technical requirements to fibre ropes and tethers for offshore mooring have not been changed compared to the October 2010 issue of this document.

— The document title has been changed from 'Offshore Mooring Fibre Ropes' to 'Offshore Fibre Ropes'.
— Recommendations have been removed for implementation into DNV-RP-E304 with new title 'Condition Management of Offshore Fibre Ropes' and a new DNV-RP-E305 'Design, Testing and Analysis of Offshore Fibre Ropes'.
— Chapters 1 and 2 have been restructured.
— Terminology changes:
  — The term '3-T performance characteristics' has been introduced.
  — The term 'performance description' has been introduced.
  — The term 'tether' is used for lines that are not intended for bending under applied tension.
  — The term 'line' is used rather than 'fibre-rope assembly'.
  — The term 'transport weight' has been introduced.
  — The term 'system integrator' is used rather than 'user'.
  — The term 'nominal load-bearing linear density' has been introduced.

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

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SECTION 1
GENERAL

A. About this standard

A 100 Introduction
101 This Standard covers technical requirements to offshore fibre ropes and offshore fibre tethers, and requirements to documentation for verification and certification.
102 The current, official issue of this standard and other DNV service documents are available at http://www.dnv.com/resources/rules_standards/index.asp.

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

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A 200 Objective
201 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.

A 300 Structure
301 Chapter 1 (this chapter) provides a general introduction with overview, definitions, general provisions and references relevant for Chapter 2 and Chapter 3. Chapter 2 provides the requirements of this standard. Chapter 3 covers the process of certification.
302 It has been attempted to structure Chapter 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.
303 Requirements pertaining to the service phase and condition management are thus presented prior to requirements pertaining to design and requirements to materials.

B. Scope of this standard

B 100 General
101 This standard provides requirements to materials, design, manufacture and testing of offshore fibre ropes and tethers, which are subject to verification or certification.
102 It may also serve as a technical reference document in contractual matters between system integrator and manufacturer.

B 200 Application areas
201 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.
The yarn testing for deliveries as required by this standard is aimed at verifying the 3-T performance characteristics that have already been determined by testing according to Standard for Certification No. 2.9, Approval Programme No. 322.

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202 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.
203 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.

204 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.

B 300 Mooring applications

301 Typical mooring applications areanchoring 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.

B 400 Underwater deployment and recovery applications

401 Reference is made to DNV-OS-E407 for more information.

B 500 Types of offshore fibre ropes and tethers

501 This standard covers offshore fibre ropes and offshore fibre tethers that are manufactured using aramid, polyester, HMPE, LCAP, or polyamide 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 will be provided in DNV-RP-E305.

C. References

C 100 General

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

102 The latest edition of the referenced document (including amendments) should apply.

C 200 Normative References

201 The referenced documents listed in Tables B1 through B4 include provisions, which through reference in the text constitute requirement of this standard.

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Table B2 DNV Standard for Certification

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<tr>
<td>No.2.9</td>
<td>Approval Programme No. 322, Yarns for Offshore Mooring Fibre Ropes. Approval Programme No. 322, Manufacturers of Offshore Fibre Yarns: planned re-issue 2013.</td>
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Table B3 DNV Recommended Practices

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Guidance note:

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<td>CI 1503</td>
<td>Test Method for Yarn-on-Yarn Abrasion.</td>
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<td>ISO 3344</td>
<td>Reinforcement products - Determination of moisture content.</td>
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C 300 Informative references

301 The referenced documents listed in Tables B5 through B7 may be useful to the users of this standard.

Table B5 DNV Offshore Standard

<table>
<thead>
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<th>Reference</th>
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<td>DNV-OS-C501</td>
<td>Composite Components.</td>
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Table B7 Other References

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<tr>
<td>API RP 2I</td>
<td>In-service Inspection of Mooring Hardware for Floating Structures.</td>
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<td>API RP 2SK</td>
<td>Design and Analysis of station-keeping systems for Floating Structures.</td>
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<td>API RP 2SM</td>
<td>Recommended Practice for Design, Manufacture, Installation, and Maintenance of Synthetic Fibre Ropes for Offshore Mooring.</td>
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<td>CI 1500</td>
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<td>OCIMF</td>
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D. Definitions

D 100 Verbal forms

101 The following verbal forms are used in this document.

Shall: Indicates a mandatory requirement to be followed in order to conform to the standard.

Should: Indicates a recommendation that a certain course of action is preferred or particularly suitable. Alternative courses of action are allowable under the standard when agreed between contracting parties, but shall be substantiated for approval by the independent verifier.

May: Indicates permission, or an opinion, which is permitted as a part of conformance with the standard.

Can: Indicates a conditional possibility.

D 200 Terms

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

3-T: The load-bearing capability of synthetic-yarn materials is referred to as 3-T (triple-T) since it depends on the combination of the critical parameters ‘tension’, ‘temperature’ and ‘time’.

Guidance note:
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.

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Aramid: Para-aramid.

Change in Length (ΔL): The increase or decrease in rope/tether length resulting from a change in tension, or time under constant tension. The change-in-length is the same as the term ‘stretch’ and is given in metres.

Change-in-length performance: The length and dynamic stiffness of the fibre rope/tether as function of loading sequence and time.

Guidance note:
The dynamic stiffness changes with mean-tension and amplitude of loading, and loading history.

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Combined loading: In addition to axial loading, combined loading includes bending or twisting.

Condition management programme: Inspection plan, measurements and activities performed regularly during the service life in order to assure the condition of the offshore fibre rope or tether.

Core: A parallel bundle of load-bearing elements (e.g. subropes) in an offshore fibre tether.

Creep failure: The transition between stage II and stage III creep for HMPE load-bearing fibre.

Cyclic Endurance: The ability to withstand prolonged cyclic loading with a controlled effect on the performance characteristics.

DDRS: Deepwater Deployment and Recovery System; see DNV-OS-E407.

Design Range: The difference between the highest occurring tension and the lowest occurring tension in the fibre rope/tether.

Design Verification Report (DVR): Report issued by the independent verifier after review and evaluation of the design documentation.

dtex: A measurement unit for linear density, i.e. weight per unit length of textiles: tex = 10^{-3} \times g/m, dtex = 10^{-4} \times g/m, ktx = g/m, and Mtex = kg/m.

Dynamic stiffness: The stiffness of a rope/tether subjected to harmonic or irregular cyclic tension variations.

FEM: Finite Element Modelling.

Fibre rope: The free length of rope (and sheathing as applicable), excluding terminations (splices and eyes) and termination hardware.

Fibre-rope segment: Fibre rope with terminations, excluding termination hardware.

Fibre tether: The load-bearing core with sheathing, excluding terminations (splices and eyes) and termination hardware.

Fibre-tether segment: Fibre tether with terminations, excluding termination hardware.

Filter: A barrier towards ingression of foreign matter, which is applied underneath the jacket.

Guidance Note: 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.
**HMPE:** High-Modulus PolyEthylene.

**Insert:** 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.

**ITP:** 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.

**ktex:** A measurement unit for linear density, i.e. weight per unit length of textiles: tex = $10^{-3} \times \frac{g}{m}$, dtex = $10^{-4} \times \frac{g}{m}$, ktex = $\frac{g}{m}$, and Mtex = $kg/m$.

**Line:** Fibre-rope or fibre-tether segment with designated termination hardware.

**Long-term mooring:** Anchoring of a unit at the same location for more than 5 years.

**Long-term mooring system:** Mooring system that is installed for a design life of five years or more.

**Marine grade of yarn:** 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.

**MBS:** 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.

---end---of---Guidance---note---

**MLA:** Mechanical Lifting Appliance; see DNV-OS-E407.

**Mobile mooring:** Anchoring at a specific location for a period less than 5 years.

**Mobile mooring system:** 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.

**Mtex:** A measurement unit for linear density, i.e. weight per unit length of textiles: tex = $10^{-3} \times \frac{g}{m}$, dtex = $10^{-4} \times \frac{g}{m}$, ktex = $\frac{g}{m}$, and Mtex = $kg/m$.

**Nominal Load-bearing Linear Density (NLLD):** The aggregate linear density of the load-bearing yarns as stated by the yarn manufacturer.

**Guidance note:**
There is no testing of rope or tether required to determine nominal load-bearing linear density.

---end---of---Guidance---note---

**Offshore fibre rope:** A synthetic-fibre line tailored for offshore application under tension with or without bending.

**Offshore fibre tether:** A synthetic-fibre line tailored for offshore application under tension without bending.

**Offshore fibre yarn:** Yarns that through adequate processing and treatment is fit for service as load-bearing yarns in offshore fibre ropes and tethers.

**Original length:** The length of the fibre rope or tether as it has been produced is called Original length. 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.

**Guidance note:**
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.

---end---of---Guidance---note---

**Performance characteristics:** The performance characteristics are the properties that define the margins towards failure for each failure mode, and the properties that describe how the line performs in the application.

**Reference tension:** A constant tension of $5 \times \frac{N}{k tex}$ under which Original Length is measured after a minimum of 17 minutes.

**Rope:** A flexible line intended for loading in tension, with or without bending.

**Performance description:** This is a document that is issued by the manufacturer to describe how the rope or tether performs in the application.

**Qualification:** Technology Qualification is defined in DNV-RP-A203.

**S:** The letter 'S' is used to denote the left-hand orientation of a rope or subrope strand. The same definition is also used for yarns.

---
**Sheathing:** Protective jacket and soil barrier (if present).

**SSA:** Safe Service Assessment is a method for assessing residual life based on an appropriate design curve for ‘3-T’.

**Guidance note:**
Recommendations concerning SSA methodologies will be provided in DNV-RP-E304.

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**Stiffness:** Stiffness, \( K \), is the ratio of change in tension to the corresponding change in length.

**Strain:** Strain, \( \varepsilon \), is the ratio of change-in-length, \( \Delta L \), to the original length of the rope, \( L_0 \).

**Guidance note:**
The strain value can also be based on another reference length for the rope, \( L_r \).

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**Strand:** The principal component of the rope or subrope. 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.

**Stress rupture:** Breakage of a polyester, para-aramid or polyamide fibre due to prolonged application of tension.

**Stretch:** The change in rope length, \( \Delta L \), as result of change in tension. The ‘change-in-length’ has the unit of length in metres.

**Subrope:** Several subropes are assembled in a parallel bundle to form a load-bearing core.

**Guidance note:**
Subropes are not referred to as “rope” in this standard, but they are indeed ropes in their own right.

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**System Integrator:** 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. The System Integrator is responsible for how the finalised system delivers its functions in the defined service scenarios.

**Technology Qualification:** Technology Qualification is defined in DNV-RP-A203.

**Termination hardware:** 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. The spool thimble is most commonly used.

**Test unit:** For manufacturing of steel termination hardware, a test unit is defined as items from the same heat of steel and same heat-treatment batch.

**Tether:** A flexible line intended for loading in tension, without bending.

**tex:** A measurement unit for linear density, i.e. weight per unit length of textiles: \( \text{tex} = 10^{-3} \times g/m \), \( \text{dtex} = 10^{-4} \times g/m \), \( k\text{tex} = g/m \), and \( M\text{tex} = kg/m \).

**Transport weight:** The weight of the fibre-rope or fibre-tether segment with a water content that is representative for outdoor conditions, after heavy rain and allowing excess water to drain off.

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

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**Z:** The letter ‘Z’ is used to denote the right-hand orientation of a rope or subrope strand. The same definition is also used for yarns.

**202** Further terms will be defined in DNV-RP-E304 and in DNV-RP-E305.
CHAPTER 2

REQUIREMENTS

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SECTION 1
GENERAL

A. Introduction

A 100 Objective
101 This chapter describes documentation requirements and technical requirements to fibre ropes and tethers in offshore applications.

B. Marking

B 100 General
101 Each offshore fibre 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.

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B 200 Twist Marker
201 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.

C. Transport

C 100 General
101 Offshore fibre ropes and tethers should be protected from direct sunlight.
102 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.

D. Service

D 100 General
101 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.

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102 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.

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D 200 Protection cloth for spliced eyes
201 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.
202 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.
203 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---

204 The splices and eyes should have the same or better resistance to soil ingress as the fibre rope.
205 If the rope is equipped with a filter then this filter shall be continuous throughout the termination area.
206 The fibre-rope segment shall be free flooded, including in the eye regions.

D 300 Offshore Mooring
301 The entire length of line shall be submerged at all times during service.
302 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.
303 The load-bearing parts of the line shall be adequately protected from marine growth. Hard marine growth shall not occur on load-bearing yarns.
304 A mobile mooring system shall be operated with the required margins against failure, ref. DNV-OS-E301.
305 A long-term mooring system shall be operated with the required margins against failure, ref. DNV-OS-E301.

Guidance note:
For a mobile mooring system it is a requirement of DNV-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---

306 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:
— seabed 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.

D 400 Underwater Deployment & Recovery
401 Reference is made to DNV-OS-E407.

E. Condition management

E 100 General
101 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.
102 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.
103 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 DNV-OSS-101 and DNV-OSS-102 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---
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.

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.

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

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.

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

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

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.

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.

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

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.

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

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

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.

The design range is the difference between the highest permissible tension and the lowest permissible tension in the rope. Standard for Certification No. 2.9, Approval Programme No. 322 is formulated to take these aspects into account.

In this standard, a distinction is made between ropes that can tolerate working in deflection, and tethers which do not.

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 DNV-RP-E305.
F 300 Terminus

301 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.

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

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

![Figure 1](image)

Fibre-tether segment fitted on spool thimble.

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

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

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

Guidance note:
For termination hardware made from other materials than steel should be qualification in accordance with DNV-RP-A203.

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

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

306 Shackles and H-links shall comply with DNV-OS-E302. Sockets shall comply with DNV-OS-E304.
SECTION 2
REQUIREMENTS TO MATERIALS

A. Load-bearing yarn

A 100

101 The 3-T performance characteristics of the yarn shall be sufficient for the designated service.
102 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’ will be provided in DNV-RP-E305. They express the load-bearing capability of the yarn, and the effect of temperature.

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

B. Terminations hardware

B 100 General

101 Termination hardware may be cast, forged, machined or welded from plates/tubes.
102 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.
103 The preparation of test pieces and the procedures used for mechanical testing shall comply with the relevant requirements of DNV-OS-B101.
104 The tensile test values should satisfy the requirements of the specified material.

Guidance note:
Sound judgement is encouraged.

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

B 200 Cast and forged thimbles

201 The materials shall satisfy a Charpy V-notch impact toughness of 50 J at -20ºC.
202 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. DNV-RP-E305 will provide additional notes concerning mechanical testing.
If an alternative test program is applied then this shall be rigorously substantiated.

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

203 The test pieces for mechanical testing shall be taken at 1/3 thickness from the surface at the critical section.
204 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.
205 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.

B 300 Manufacturing from rolled plate

301 The material in plates (and tubes) shall comply with the requirements to mechanical properties of grades NV D as given in DNV-OS-B101.
302 Fabrication and non-destructive testing shall be in accordance with DNV-OS-C401. Welds shall be considered as special category.

B 400 Other termination elements

401 Shackles and H-links shall comply with DNV-OS-E302. Sockets shall comply with DNV-OS-E304.
402 The material in custom-made termination elements shall comply with DNV-OS-E302 and/or DNV-OS-C401, as appropriate.
B 500  Other materials

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

Guidance note:
Recommendations will be provided in DNV-RP-E305.
SECTION 3
PERFORMANCE CHARACTERISTICS

A. Introduction

A 100 General

101 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 will be provided in DNV-RP-E305.

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

B. Load-bearing yarn

B 100 General

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

102 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.

C. Fibre-rope or fibre-tether segment

C 100 Tension-Time-Temperature performance characteristics (3-T)

101 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.

102 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 will be provided in DNV-RP-E305.

C 200 Cyclic endurance

201 The cyclic endurance shall be verified for long-term mooring systems and ropes for Deepwater Deployment & Recovery Systems, with subsequent examinations and tests.

202 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.

C 300 Splice integrity

301 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 will be provided in DNV-RP-E305.

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

C 400 Change-in-length characteristics

401 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.

402 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.

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

C 500 Torque and twist characteristics

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

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

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

C 600 Breaking Strength

601 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.

602 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.

603 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.

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

C 700 Resistance to soil ingress of mooring lines

701 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.

702 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.

703 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---

C 800 Hysteresis heating
801 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---

C 900 Low-tension durability
901 For aramid yarn materials, low-tension durability shall be considered as appropriate.

D. Termination Hardware

D 100 General
101 The requirements to material properties of the termination hardware are given above.
102 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.
SECTION 4
DESIGN VERIFICATION

A. Documentation Requirements

A 100 General
101 This section covers documentation requirements.
102 The design verification shall confirm that the design of the line satisfies the system integrator specification and the requirements of this standard.
103 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.
104 A design verification carried out on an offshore fibre rope or offshore fibre tether is only valid for that specific line.
105 For long-term moorings, the design verification is only valid for the designated location.
106 The linear density of yarns should be stated in dtex.
107 The linear density of strands and subropes should be stated in ktex.
108 The linear density of ropes should be stated in ktex or Mtex.

A 200 System integrator
201 This section provides the requirements to documentation from the system integrator for the purpose of design verification of the offshore fibre ropes or tethers.
202 The system integrator shall provide the rope manufacturer with a rope specification.
203 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.
204 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.

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

205 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.

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

206 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.

A 300 Rope Manufacturer

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

302 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.

303 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.

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

305 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 will be provided in DNV-RP-E305.

306 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 will be provided in DNV-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.

307 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.

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

— the rope jacket
— the filter, if applicable.

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

310 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.

311 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.

312 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.

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

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

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

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

A 400 Yarn Manufacturers

401 The documentation requirements to the manufacturer of the load-bearing yarn are the same as the documentation requirements of Standard for Certification No. 2.9, Approval Programme No. 322, and as stated in this standard for testing of deliveries.

A 500 Termination Hardware Manufacturers

501 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

A. Introduction

A 100 General

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

102 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 will be provided in DNV-RP-E305.

B. Testing of load-bearing yarn

B 100 General

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

102 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.

103 The manufacturer should carry out testing according to Table B1 as a minimum and keep records of all testing.

104 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 B1.

<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>DNV-RP-E305</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 DNV-RP-E305.
C. Testing of rope and tether

C 100  General

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

102  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.

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

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

C 200  Offshore Mooring

Table C1 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>

Table C2 Requirements to test specimens for long-term mooring

<table>
<thead>
<tr>
<th>Type of test</th>
<th>Number of test specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-T performance characteristics, new</td>
<td>To be determined on case-by-case basis. Subropes should be used if relevant.</td>
</tr>
<tr>
<td>Cyclic endurance test</td>
<td>1 fibre-rope segment with termination hardware from the actual delivery</td>
</tr>
<tr>
<td>3-T performance characteristics, used</td>
<td>To be determined on case-by-case basis for the cyclic endurance tested rope. 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 5 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 will be provided in DNV-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---

201  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---

C 300  Testing of maximum temperature due to hysteresis heating in mooring lines

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

302  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.

---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---
C 400 Deepwater Deployment & Recovery

401 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.

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

D. Test methods

D 100 General

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

102 In addition to the recommendations that will be provided in DNV-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.

103 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 system integrator specification. Due to the dependence of rope length on actual loading, the testing specification should reflect the actual loading scenario as closely as possible.

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

105 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.

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

D 200 Termination hardware

201 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.

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

202 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 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.

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

D 300 Materials testing of termination hardware

301 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 will be provided in DNV-RP-E305.

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

302 Shackles and H-links shall comply with DNV-OS-E302. Sockets shall comply with DNV-OS-E304.
CHAPTER 3

CLASSIFICATION AND CERTIFICATION

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SECTION 1
CLASSIFICATION AND CERTIFICATION

A. Classification

A 100 General
101 The principles, procedures, applicable class notations and technical basis for offshore classification are given in DNV-OSS-101 for Offshore Drilling and Support Units and DNV-OSS-102 for Floating Production and Storage Units.

Guidance note:

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

B. Certification

B 100 General
101 The following requirements will be applied in conjunction with DNV certification according to this standard.

B 200 Main elements in certification
201 The main elements in certification of offshore fibre ropes and offshore fibre tethers are Approval of Manufacturer, design verification and fabrication survey.

B 300 Approval of Manufacturer
301 Load-bearing yarn, fibre-rope or tether segments and termination hardware shall be manufactured at works which have been approved by DNV.

Guidance note:
Approved manufacturers are published on DNV Exchange on the Internet. (http://exchange.dnv.com/tari)
The approval of yarn converters is covered by the approval of manufacturers for load-bearing yarns.

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

302 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.

303 Detailed programmes for approval are given in Standards for Certification No.2.9, Approval Programmes No. 321 for rope manufacturers and No. 322 for yarn manufacturers.

B 400 Deviations and test waivers
401 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. Any such request should be included in the Request for Certification.

402 Any deviations, exceptions and modifications to referenced codes and standards shall be documented and agreed between system integrator, manufacturer and DNV.

B 500 Design Verification
501 Design verification covers review of specifications and documentation listed in Chapter 2 and issuance of Design Verification Report.

B 600 Survey during manufacture
601 Fabrication survey shall be based on attending tests and inspections, monitoring manufacturing, and review of records.

602 Follow-up and witness of the production shall be based on the manufacturing description and the Inspection & Test Plan.
C. Certification of yarns

C 100 Load-bearing yarns

101 Load-bearing yarns shall be certified by DNV. 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.

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

102 Certification of yarn consists of monitoring and witnessing of testing according to an Inspection & Test Plan (ITP).

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

104 The following particulars will be listed in the certificate:

- purchasers 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 Chapter 2. The extent of survey and testing should be taken as given by the Approval of Manufacturer documentation. An example of a load-bearing yarn certificate is found in Appendix E.

C 200 Non-load-bearing components

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

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

D. Certification of termination hardware

D 100 General

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

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

103 One DNV 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.

E. Certification of Lines

E 100 Introduction

101 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 Chapter 2.

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

103 One DNV 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.

104 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).

F. Special service

F 100 General
101 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.
102 For mooring lines, reference is made to Chapter 2, Section 2 of this document for special service categories.

F 200 Sea-bed contact
201 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.

F 300 External contact
301 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.
302 Full qualification entails substantiating that all failure modes are managed.

G. Re-certification of Offshore Fibre Ropes and Tethers

G 100 General
101 Used lines may be re-certified for continued or prolonged service according to the provisions of this standard.
102 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.
103 The requirements for re-certification will be determined by DNV’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 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---of---G-u-i-d-a-n-c-e---n-o-t-e---

104 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.
105 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 may be endorsed without design verification of the repair.
106 The repair work will be subject to DNV survey.
SECTION 2
WORK PROCESS FOR CERTIFICATION OF LINES

A. General

A 100 Introduction
101 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.

A 200 Request for certification
201 The request for certification should be sent to DNV 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 application
— 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.

A 300 Pre-production Meeting
301 A pre-production meeting shall be held at the manufacturer’s premises prior to start of the certification process.

302 The meeting shall include representatives from the following organisations:

— manufacturer of the fibre ropes
— DNV surveyor from local survey station appointed to follow up production and testing
— representative from DNV’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.

303 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.

304 The presentation made by DNV will include:

— presentation of DNV-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.

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

B. Design Verification

B 100 General

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

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

C. Design Verification Report

C 100 General

101 DNV 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.

D. Start-up of production

D 100 General

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

102 This will be notified in an e-mail to the manufacturer from the DNV surveyor.

E. Survey during production and testing

E 100 Scope of survey

101 Check certificates for load-bearing yarns.

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

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

104 Number of rope tests to be witnessed has to be decided by the attending DNV 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.

105 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.

106 Scope of survey at the rope manufacturer can be found in Appendix A of this standard.
F. Testing

F 100  General
101  The testing shall be carried out according to the provisions set forth in the testing specification.
102  The testing specification for all tests and reporting is subject to approval by DNV.
103  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.

104  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.

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.

---end---of---Guidance---note---

G. Certificates

G 100  Certificates for Load-bearing Yarns
101  The load-bearing yarn for the fibre ropes shall be ordered with DNV certification at the works with reference to this standard. The certificate format and contents for compliance with this standard is shown in Appendix E.

G 200  Certificates for Termination Hardware
201  Termination hardware shall be ordered with DNV certification at the works, with reference to this, or the appropriate other, standard as detailed in Chapter 2.
202  The certificate format and contents for compliance with this standard is shown in Appendix D.

G 300  Certificates for Offshore Fibre Ropes and Offshore Fibre Tethers
301  The certificate format and contents for compliance with this standard is shown in Appendix B for Long Term Mooring and in Appendix C for Mobile Mooring.

Guidance note:
Other certificate formats will be made available as examples when they have been developed.

---end---of---Guidance---note---
**APPENDIX A**

**SCOPE OF SURVEY AT ROPE MANUFACTURER**

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

An Inspection & 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 intervention points shall as a minimum include following:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Ref. in OS</th>
<th>DNV 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 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 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 installation. 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 shall be present for survey. Advance notification to DNV shall be given in writing or any other agreed system of notification. Work shall not proceed beyond a hold point without DNV present or, in exceptional cases where presence is waved, without first obtaining a written authorisation from DNV.
Witness point (W): A point where DNV may be present for survey, at their discretion. Advance notification to DNV shall be given in writing or any other agreed system of notification. Work may proceed beyond a witness point with or without DNV 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.
APPENDIX B
EXAMPLE OF CERTIFICATE FORMAT FOR LONG-TERM MOORINGS

This Certificate is issued for the information of interested parties to indicate compliance with the provisions of DNV Offshore Standard DNV-OS-E303 (hereinafter referred to as "the Standard").

Particulars of fibre rope assembly:
- Fibre rope segment identification:
- DNV Certificates for termination hardware:
- Procedure for handling and installation:
- Manufactured by:
- In-service condition assessment programme:
- Minimum Breaking Strength [kN]:
- Assembly new length and definition:
- Installation / location:
- Design Verification Report:

THIS IS TO CERTIFY:
1. That the fibre rope assembly has been subject to design review, manufacturing survey and testing according to the provisions of the Standard; and
2. That for its designated service the fibre rope assembly has been found to be in compliance with the requirements of the Standard.

Remarks/Recommendations:

This Certificate is valid until (yyyy-mm-dd) subject to the provisions set forth in the in-service condition assessment programme, and as otherwise stated on the above referenced Design Verification Report.

Completion date of audit on which this Certificate is based: (yyyy-mm-dd)

Issued at (place) on (yyyy-mm-dd)

(Signature)
Surveyor

for Det Norske Veritas AS

DET NORSKE VERITAS AS
APPENDIX C
EXAMPLE OF CERTIFICATE FORMAT FOR MOBILE MOORINGS

DET NORSKE VERITAS
CERTIFICATE
FIBRE ROPE ASSEMBLY
Mobile Mooring

This Certificate is issued for the information of interested parties to indicate compliance with the provisions of DNV Offshore Standard DNV-OS-E303 (hereinafter referred to as "the Standard")

Particulars of fibre rope assembly:
Fibre rope segment identification: ____________________________________________________________
DNV Certificates for termination hardware: __________________________________________________
Procedure for handling and installation: ______________________________________________________
Manufactured by: _______________________________________________________________________
Minimum Breaking Strength [kN]: __________________________________________________________
Assembly new length and definition: _______________________________________________________
Number of subrope(s): __________________________________________________________________
Number of strands per subrope: ___________________________________________________________
Nominal load-bearing yarn linear density [dtex] and yarn designation: ___________________________
Change-in-length testing according to: ______________________________________________________
Change-in-length test report: ______________________________________________________________

Segment Characteristics
Type of rope:  
☐ Parallel subrope(s)  ☐ Single rope
☐ Neutral  ☐ Matched
Torque:  
☐ Individual  ☐ Paired
Splice arrangement:  
☐ Helical  ☐ Braided  ☐ Parallel yams
Construction:  

THIS IS TO CERTIFY:
1. That the fibre rope assembly has been subjected to design review, manufacturing survey and testing according to the provisions of the Standard; and
2. That for its designated service the fibre rope assembly has been found to be in compliance with the requirements of the Standard.

Remarks/Recommendations:

This Certificate is valid until (yyyy-mm-dd) subject to the provisions set forth in the procedure for handling and installation.

Completion date of audit on which this Certificate is based: (yyyy-mm-dd)
Issued at (place) on (yyyy-mm-dd)

for Det Norske Veritas AS

(name)
Surveyor
APPENDIX D
EXAMPLE OF CERTIFICATE FORMAT FOR TERMINATION HARDWARE

Purchaser / Rope manufacturer
Manufacturer of termination hardware:  
Manufacturer’s order No.:  
Purchaser / Rope manufacturer:  
Purchaser’s order No.:  
Destination Unit / ID number:  

Description of Product
MBS of rope assembly:  
Process of manufacturing:  
Heat treatment, if cast:  
Material Certificate No.:  
Material Specification:  
Number of termination hardware:  
Drawing number / Approval reference:  
Id. marking:  
Location of Id. marking:  

Results from testing
Mechanical Properties of the Material

<table>
<thead>
<tr>
<th>Cast/Plate No.</th>
<th>Test No.</th>
<th>Yield stress, ( R_m )</th>
<th>Tensile strength, ( R_m )</th>
<th>Elongation, ( A )</th>
<th>Reduction of area, ( Z )</th>
<th>Charpy V-notch energy, ( A )</th>
</tr>
</thead>
<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Remarks:
Welding Report Ref. No.:  
NDT Report Ref. No.:  

THIS IS TO CERTIFY:
that the termination hardware(s) have been tested and inspected and found to be in accordance with the requirements of DNV-OS-E303.

issued at (place) on (yyyy-mm-dd)
for Det Norske Veritas AS

(name)
Surveyor
APPENDIX E
EXAMPLE OF CERTIFICATE FORMAT FOR LOAD-BEARING YARNS

This Certificate is issued for the information of interested parties to indicate compliance with the provisions of DNV Offshore Standard DNV-OS-E303 (hereinafter referred to as "the Standard").

Particulars of loadbearing yarns:

Material / Fibre type: .................................................................
Loadbearing yarn designation: .................................................
Linear density [dtex]: ................................................................
Amount of twisting at delivery: ...................................................
Type and amount of coating: ......................................................

Characteristic values, force/strain/modulus: [N/10^6][N/10^6][%]
Characteristic coefficients, stress rupture: .................................
Yarn-on-Yarn abrasion: ............................................................
Design Range [N/0.1 tex] ...........................................................
Design Temperature [°C] ............................................................
Designated fibre-rope production: .............................................

THIS IS TO CERTIFY:
1. That the loadbearing yarn has been subject to manufacturing survey and testing according to the provisions of the Standard; and
2. That the loadbearing yarn has been found to be manufactured at a facility with DNV AoM Certificate stated above.

Remarks/Recommendations:

Completion date of audit on which this Certificate is based: (yyyy-mm-dd)

Issued at (place) on (yyyy-mm-dd)

for Det Norske Veritas AS

(name)

Surveyor