FIBRE ROPES FOR OFFSHORE SERVICES

NR432 – DECEMBER 2024

RULE NOTE

BUREAU VERITAS

BUREAU VERITAS
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These rules are provided within the scope of the Bureau Veritas Marine & Offshore General Conditions, enclosed at the end of Part A of NR467, Rules for the Classification of Steel Ships. The latest version of these General Conditions is available on the Bureau Veritas Marine & Offshore website.

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FIBRE ROPES FOR OFFSHORE SERVICES

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Section 1 General

1 General

1.1 Scope

1.1.1 This Rule Note applies to fibre ropes used as load-bearing components in the stationkeeping system of a floating offshore unit, or for other offshore applications, as defined in [1.2].

1.1.2 This Rule Note specifies the requirements for the design, manufacturing, quality control, testing and certification of fibre ropes and associated fibre materials (see Sec 2 to Sec 6). Rope testing procedures are defined in App 1.

1.1.3 This Rule Note also provides requirements related to the design and operating criteria of stationkeeping systems that include fibre rope segments (see Sec 7) and guidance for modelling in numerical analysis (see App 2).

1.2 Field of application

1.2.1 Fibre ropes for deepwater stationkeeping systems of oil and gas offshore units

This Rule Note applies to fibre ropes used as elements of anchoring lines for the stationkeeping at their operating site of permanent or mobile floating offshore units, for the oil and gas industry.

These units are generally deepwater installations, and systems where the rope is a “critical component” for the safety and for the asset integrity.

The requirements and recommendations of this Rule Note are consistent with ISO 18692 series of standards.

Note 1: The certification of ropes is to be generally performed as a part of activities for the classification of an offshore unit, for the assignment of a classification notation **POSA** covering the stationkeeping system of that unit (see NR493), or can be performed when requested by the manufacturer.

Note 2: The following fibre materials are currently used (or considered): polyester, high modulus polyethylene (HMPE), aramid and polyarylate (see Sec 3).

1.2.2 Fibre ropes for stationkeeping systems of marine renewable energies floating units

This Rule Note also applies to fibre ropes used for the stationkeeping at their operating site of marine renewable energies (MRE) floating units.

These units are generally located in intermediate or shallow waters. They generally represent a lower risk for life safety (as the unit is most of the time unmanned) and for the environment (limited risk of pollution).

Note 1: In addition to the materials quoted in [1.2.1] Note 2, polyamide is also considered for MRE applications (see Sec 3).

1.2.3 Tethers, hangers and other underwater offshore applications

This Rule Note may also apply to fibre ropes used in similar conditions as stationkeeping lines (i.e. free spanning between terminations) such as:

- tension members (tethers) in subsurface systems
- construction lines (hangers) between part of multibody floaters
- tendons of Tension Leg Platforms (TLP)
- other offshore underwater applications, when appropriate.

1.2.4 Other marine applications

This Rule Note may be referred to when agreed by involved parties.

However, this Rule Note does not cover the certification of synthetic fibre ropes for the following marine applications:

- Single Point Mooring (SPM) hawsers used for temporary loading / offloading operations
- jetty mooring lines
- towing lines, mooring lines (ship to terminal, ship to ship).

Note 1: The type approval and the inspections of jetty mooring lines in the scope of **POSA JETTY** notation may be performed according to the requirements of OCIMF Mooring Equipment Guidelines 4th edition (MEG4).

Note 2: The type approval (if requested) and the inspections of ropes for SPM hawsers, towing lines and mooring lines is performed based on NR216, Ch 10, [6], with reference to recognized product standards (such as ISO standards, OCIMF guidelines or Cordage Institute documents).

1.2.5 Termination fittings

Termination fittings, such as thimbles or similar devices are covered by this Rule Note only for their interface properties with the rope and for testing (see Sec 4, [3] and App 1).

Shackles or other connecting devices are not covered by this Rule Note.

Note 1: When requested and/or for classification purpose, termination fittings are to comply with the relevant provisions of NR493.

1.3 Definitions

1.3.1 Applicable definitions

The terminology related to the description, design, construction and manufacturing of fibre ropes is given in the following standards:

- ISO 18692-1 for stationkeeping applications
- ISO 1968 for general vocabulary.

Further relevant definitions are given in [1.3.2] to [1.3.14], for reference or as complement.

1.3.2 Fibre

In the present document, the term "fibre" is used to designate a multi-filament fibre, resulting from extrusion and subsequent treatments of a synthetic material (natural and mineral fibres are excluded).

1.3.3 Yarn

A yarn is a bundle of fibres that are assembled together, generally by twisting, in a long continuous length.

1.3.4 Strand

A strand is a bundle of yarns that are generally twisted together. Several strands are twisted or braided together to form a rope (or subrope).

1.3.5 Subrope

A subrope is a twisted or braided rope that is used as an element of a parallel construction rope.

1.3.6 Lay length

The lay length is defined as the required distance along the axis of a rope (or strand) to complete one revolution of the strand (or yarn) around the rope (or strand) axis.

1.3.7 Quasi-static stiffness

The quasi-static stiffness is the ratio of the variation of tension to the variation of elongation under slowly varying environmental conditions. See App 2, [2].

1.3.8 Dynamic stiffness

The dynamic stiffness is the ratio of the variation of tension to the variation of elongation under cyclic loading induced by environment (e.g. waves). See App 2, [3].

1.3.9 Minimum Breaking Strength (MBS)

The MBS of the rope is defined as the specified minimum value of the tension that the rope is to withstand when tested to rupture, following the procedure defined in this Rule Note.

Note 1: The MBS is thus defined as that of the spliced (terminated) rope.

Note 2: For polyamide ropes, the MBS is the minimum wet breaking strength.

1.3.10 Rope model

A rope model is a set of ropes having, over a range of sizes, common characteristics including fibre and other materials, construction and method of manufacturing for the rope core, the rope protection, and the terminations, and dimensional characteristics such that a rope in one size can be considered as homothetic to a rope of another size.

Note 1: A rope model generally corresponds to a product in a Manufacturer's catalogue, provided same fibre(s) and other materials are used.

Note 2: Two ropes of the same model have, in principle, the same number of elements (strands, subropes …) and all dimensions (diameters, lay length …) in same proportion or, for a parallel construction, can be made of a different number of identical subropes.

1.3.11 Rope size

The rope size is a nominal dimension (e.g. diameter or circumference) of the cross section of a rope, or a reference number (in ISO rope standards), or the resulting MBS of that rope.

Note 1: For the purpose of this Rule Note, the MBS is generally used to indicate rope size.

1.3.12 Rope material

The material quoted in the designation of a rope in this Note, (e.g. an "aramid rope") corresponds to the material of the rope core.

1.3.13 Bedding-in

The bedding-in is the process of stabilization of rope mechanical properties induced by loading and successive cycling of the rope in its early life. See App 2, [1.3].

1.3.14 Range of water depth

Unless otherwise agreed with the Society, the range of water depths associated with the terms "deepwater", "intermediate water", and "shallow water" depth are defined as follows:

- Shallow water: 0 - 150m
- Intermediate water: 150 - 500m
- Deepwater: > 500m

1.4 Referenced documents

1.4.1 Bureau Veritas documents

The following Society's Rules are referred to as in this Rule Note:

- NR216 – Rules on materials and welding for the classification of marine units
- NR320 – Certification scheme of materials and equipment for the classification of marine units
- NR493 – Classification of mooring systems for permanent and mobile offshore units
- NR658 – Type approval of fibres and yarns
- NI691 – Environmental conditions, loads and induced responses of marine units.

1.4.2 ISO documents

When they are referenced in this Rule Note, the following version of ISO standards is to be considered:

- ISO 1968:2004 – Fibre ropes and cordage - Vocabulary
- ISO 18692-1:2018 – Fibre ropes for offshore stationkeeping - Part 1: General specification
- ISO 18692-2:2019 – Fibre ropes for offshore stationkeeping - Part 2: Polyester
- ISO 18692-3:2020 – Fibre ropes for offshore stationkeeping - Part 3: High Modulus Polyethylene (HMPE)
- ISO 18692-4:2023 – Fibre ropes for offshore stationkeeping - Part 4: Polyarylate
- ISO 18692-5:2024 – Fibre ropes for offshore stationkeeping - Part 5: Aramid
- ISO 19901-7:2013 – Petroleum and natural gas industries – Specific requirements for offshore structures – Part 7: Stationkeeping systems for floating offshore structures and mobile offshore units.

1.4.3 OCIMF documents

When they are referenced in this Rule Note, the following version of OCIMF guidelines is to be considered:

- OCIMF – 2000 – Guidelines for the purchasing and testing of single point mooring hawsers
- OCIMF MEG4 - 2018 - Mooring Equipment Guidelines 4th edition.

Section 2 Certification Scheme

1 Certification conditions

1.1 General

1.1.1 The certification activities are performed with reference to:

- the requirements of the present Rule Note
- other Society's Rules, as applicable (see Sec 1, [1.4.1])
- ISO 18692 series, as applicable.

Reference may also be made to specific requirements of client's specification, where applicable.

1.1.2 The Society reserves the right to modify the content of the present certification scheme or associated requirements, or to refer to specific requirements for a particular product or usage or service condition.

2 Process of Certification

2.1 General

2.1.1 The certification of ropes intended for a given offshore unit involves the following steps to be carried out:

a) Type approval of the fibre material used in the rope core, following the certification scheme for H_{BV} products (see NR320, Sec 1, [4.2]). This step will result in the issuance of a type approval certificate of the fibre, usually with the fibre Manufacturer (see Sec 3).

b) Type approval of the rope following the certification scheme for I_{BV} products (see NR320, Sec 1, [4.1]), based on the design, manufacturing, and testing of a full-size prototype of the specified rope. This step will result in the issuance of a type approval certificate of the rope (See Sec 4, Sec 5 and Sec 6).

   This type approval will be valid for the manufacturing of ropes that are identical, in rope model (i.e. including fibre(s)) and in rope size, to the rope that has been prototype tested.

c) Inspection during manufacturing and testing of ropes for current production, in compliance with the type approval, resulting in the issuance of a product certificate (see NR320, Sec 1, [4.1]).

Note 1: For further manufacturing, the qualification does not need to be repeated when the ropes are identical to a rope already holding a type approval, i.e. no change is made to materials, design, nor manufacturing process.

2.1.2 During qualification, tests results from previously type approved ropes of the same model (see Sec 1, [1.3.10]) may be taken into account, subject to agreement by the Society when reviewing rope design and manufacturing specifications (see Sec 6, [1.1.3]).

2.2 Certification activities

2.2.1 Certification activities generally include the following:

a) For fibre material approval, refer to Sec 3 and NR658.

b) For rope approval:
   - review of design and manufacturing documents
   - review of fibre certification status (see Sec 4)
   - surveys during the manufacturing of a prototype rope and the preparation of rope samples for testing
   - witnessing of prototype testing
   - review of manufacturing and testing reports
   - issuance of a type approval certificate upon satisfactory completion of the procedure
   - assessment of manufacturing facilities and issuance of a recognition certificate upon satisfactory completion of the procedure (BV mode II survey as defined in NR 320).

c) For inspection during the production of ropes in accordance with the rope approval:
   - attendance to production tests and examinations as agreed for individual supplies
   - visits during manufacturing of ropes
   - visits during rope testing (where applicable)
   - issuance of a certificate of inspection for the individual supply upon satisfactory completion of the procedure.

2.3 Documentation to be submitted for approval

2.3.1 The Manufacturer is to submit the following documentation:

a) At time of application for rope qualification:
- summary of rope design (see [2.3.2])
- related production plans (when applicable)
- Manufacturer’s brochures and catalogues of products (for information)
- Reference, if any, to previously obtained qualification for the same model of rope (see Sec 6, [1]).

b) For rope qualification:
1) At start of qualification:
    - quality management system certificates
    - data of intended material (type, Supplier, and grade)
    - for HMPE, data of creep properties
    - plans for prototype testing and documentation of previously performed tests
    - documents and plans related to site and project specific aspects (marine growth ingress, seabed contact…)
    - detailed planning for design activities, prototype manufacturing, prototype testing, and subsequent rope manufacturing.
2) Before manufacturing and testing:
    - Manufacturer's design and manufacturing specifications (see [2.3.3])
    - quality plan covering all steps of manufacturing, inspection and testing
    - detailed testing procedures
    - plans and specifications for the purchase of thimbles and fittings (if any) and relevant type approval documentation
    - list of quality control procedures
    - testing reports (when available).
3) After prototype testing
    - prototype testing reports.

c) For the production of ropes in accordance with the type approval:
- rope supply data sheet (see [2.3.4])
- inspection and test plans
- testing reports (where applicable and when available).

2.3.2 Summary of rope design

A summary of rope design is to provide a general description of the rope to be qualified, including:
- identification of product (rope model)
- type of service
- rope core material (with fibre designation)
- type of construction, including type of torque behaviour
- type of protective cover and particle ingress protection
- type of terminations
- specified MBS and rope diameter
- reference assembly and interface drawings.

An example of template for the Summary of rope design is given in App 3, Tab 1.

2.3.3 Design and Manufacturing Specifications

The detailed design and manufacturing specifications are to include:
- specifications of all materials (see Sec 3 and Sec 4, [1.3])
- details of rope construction (see Sec 4, [1.2])
- details of rope protection
- details of terminations
- specification of thimbles
- manufacturing specifications, of rope and terminations including production sheets, and relevant procedures
- marking information
- quality control procedures, Inspection plans, and report forms.

An example of data sheet for details of rope construction is given in App 3, Tab 2.

2.3.4 Rope supply data sheet

A rope supply data sheet is to provide a general description of the intended supply, including:

- identification of product (rope model)
- type of service and other information on rope service conditions, as provided by Purchaser
- specified MBS and diameter
- reference type approval, with a statement of compliance by the Manufacturer
- material (with fibre designation)
- type of construction, including type of torque behaviour
- protective cover and particle ingress protection information
- type of terminations
- assembly and interface drawings
- scope of supply (for information and interface with classification activities)
- number and length of finished ropes in the supply.

An example of template for Rope supply data sheet is given in App 3, Tab 3.

2.3.5 Manufacturing records

Fabrication files are to be made available to Surveyor, at factory, including, as a minimum:

- material certificates
- production sheets
- records of controls and inspections
- testing records.

Section 3 Fibre Material

1 Fibre for rope core

1.1 General

1.1.1 For the rope core, (i.e. the load-bearing part of the rope), the following fibre materials are covered by this Rule Note:

- polyester (high tenacity)
- high modulus polyethylene (HMPE)
- aramid and polyarylate
- polyamide PA6 (high tenacity), also referred as nylon (for MRE only).

Other fibre materials and yarns made of several materials (dual fibre yarns) will be given special consideration by the Society, based on their particular properties and intended application.

1.2 Qualification

1.2.1 The fibre for the rope core (see Sec 4, [1.4]) is to be type approved by the Society, and delivered, in accordance with the requirements and procedures of NR658, complemented by the requirements of the present Section.

Compliance with NR658 is to include the specific provisions applicable to “Stationkeeping lines” (see NR658, Sec 1, [2.3.2]).

Note 1: The type approval is to be obtained by the fibre Manufacturer. For fabricated or re-processed fibre, its type approval is to be obtained by the rope Manufacturer. In this case, the type approval of the base fibre is also required (for applications other than MRE) - see NR658.

1.3 Fibre properties

1.3.1 The dry tenacity of the fibre used for the manufacturing of the rope core is to be not less than:

- 0,78 N/Tex for polyester fibres
- 3 N/Tex for HMPE fibres
- 1,8 N/Tex for aramid and polyarylate fibres
- 0,75 N/Tex for polyamide (PA6) fibres.

1.3.2 Except for HMPE, the fibre is to be a marine grade fibre, i.e. fibre provided with a coating (e.g. a marine finish) having documented properties as per NR658, Sec 2, [1.3.3].

Note 1: the coating improves the yarn-on-yarn abrasion performance of the fibre, resulting in better endurance of the rope.

Note 2: HMPE is intrinsically “marine graded”, therefore the provisions related to fibre coating in NR658 are not applicable for this material.

1.3.3 The creep properties of HMPE fibres are to be documented according to ISO 18692-3.

1.3.4 The hydrolysis properties of aramid and polyarylate fibres are to be documented according to ISO 18692-4 and ISO 18692-5.

2 Fibre for braided protective cover

2.1 General

2.1.1 The fibre for a braided protective cover (see Sec 4, [1.5.2]) is to have documented properties, in accordance with the general provisions of NR658.

The fibre is to be delivered with a work’s certificate stating compliance with the manufacturer's product specification.

2.1.2 The dry tenacity of the fibre, when used for the manufacturing of the rope cover is to be not less than:

- 0,73 N/Tex for polyester fibres
- 2,5 N/Tex for HMPE fibres
- 0,70 N/Tex for polyamide fibres.

Section 4 Rope Design and Manufacturing

1 Rope design

1.1 General

1.1.1 The rope design is to be identified, including materials, arrangement, method of manufacturing, as well as numerical data (e.g. sizes, numbers, dimensions such as twist or lay-length) for the proposed rope size, as detailed in the present Section.

1.2 Rope construction

1.2.1 Ropes are to comprise a rope core (see [1.4]), as the load-bearing part of the rope, and a rope protection (see [1.5]).

1.2.2 The details of construction and number of all components of rope core and protective cover are to be provided. The mass and dimensional characteristics of the rope are to be defined.

Note 1: An example of data sheet for details of rope construction is given in App 3, Tab 2.

Note 2: Except for particular cases, the diameter or the particulars of a specific (non-circular) cross section are given for information.

1.3 Materials

1.3.1 All materials used for rope manufacturing are to be identified and are not to be changed subsequently.

Fibres for rope core and for rope cover are to be in accordance with the relevant provisions of Sec 3.

For additional materials used for the manufacturing of rope (e.g. filter, coating or lubricant) and terminations (e.g. lining, coating), the following properties are to be provided:

- purpose
- base material
- type of construction/preparation
- brand name and reference to a specification
- dimensional properties (e.g. thickness, linear density)
- strength and performance (e.g. filtering capability), with reference to adequate standards.

1.3.2 The final acceptance of fibres and other materials for a given rope is, in any case, pending the full size testing of prototype ropes.

1.4 Rope core

1.4.1 The construction of rope core is to be such that the rope:

- has intended strength and stiffness in accordance with the product specification
- meet the performances specified in Sec 6.

The rope core is generally made of a number of identical laid or braided subropes in parallel (parallel construction rope) or can be a single laid or braided rope. Other construction methods (e.g. parallel fibre construction) will be given special consideration by the Society.

1.4.2 The construction of rope core is to be such that the rope has a torque behaviour (see Sec 7, [2.2]) being in principle one of the following:

- Torque-neutral construction:

  A construction such that rope ends do not exert a torque, or tend to rotate, when the rope is tensioned.

Note 1: Some constructions are inherently torque-neutral.

- Torque-matched construction:

  A construction such that, over a certain range of tension, the rope develops a similar torque to that of a given steel wire rope, and thus can balance the line assembly. In this case, the type and size of the matching steel wire rope are to be specified.

1.5 Rope protection

1.5.1 The rope protection is to be made of a protective cover and a particle ingress protection.

The requirements related to the protection of ropes are specified in:

- [1.5.2] and [1.5.3] for deepwater stationkeeping applications, complying with the requirements of Sec 7, [2]
- [1.5.4] for stationkeeping systems in shallow / intermediate water depths, or other cases (see Sec 7, [3].

1.5.2 Protective cover

A non-load bearing cover is to protect the rope core from mechanical damages during handling and in service.

The cover is to be permeable, to permit flooding of void spaces within the rope when immersed.

Note 1: In case of a parallel construction, the cover also has the function of holding rope core elements (subropes) together.

A braided cover is typically used.

The braided cover is to have a thickness not less than:

- 7 mm when made of polyester or polyamide for ropes with a diameter D of 100mm and above
- 0,07·D (but not less than 4mm), when made of polyester and polyamide for ropes with a diameter D less than 100mm
- 3 mm when made of HMPE
- if another material is used, a thickness providing at least an equivalent level of protection.

Coloured strands in a suitable pattern are to be provided within the braiding, as a mean to verify that the rope has not been twisted, during handling or in service.

Note 2: For the same purpose, marking by a straight line may be added as a complement.

Note 3: Other constructions of rope cover will be specially considered.

1.5.3 Particle ingress protection

For covered ropes, a particle ingress protection is to provide a secondary barrier to avoid penetration of dust or soil or other particles into the rope core (see Sec 7, [2.3]).

Note 1: This secondary barrier may be provided as an under-layer to the braided cover or other suitable arrangement.

A properly selected non-woven filtering material may be used. The filtering capability of material may be assessed by standard filtering tests, prior to the qualification test below.

Unless otherwise agreed, the particle ingress protection is to be able to prevent the ingress of particles with a size greater than 5 microns.

The arrangement and method of placement of the protective cover are to be specified (see [2.2.5]). The efficiency of the particle ingress protection is to be verified by testing in accordance with Sec 6, [5.3].

1.5.4 Intermediate / Shallow water units

The requirements given in [1.5.2] and [1.5.3] apply to floating units moored in shallow and intermediate water depths as minimum requirements. In addition, the specific degradation mechanisms as quoted in Sec 7, [3.3] are to be accounted for by the means of testing, investigation and in-situ observations following the requirements of Sec 6, [5.3.2].

2 Rope assembly

2.1 Manufacturing

2.1.1 Manufacturing specifications are to define each step of the manufacturing process, and associated setting of parameters.

Any particular aspect of manufacturing process is to be duly identified and covered by specifications and procedures.

The Society reserves the right to require specific documentation on any aspect of proposed practice.

2.1.2 Strands, subropes and rope core are to be manufactured in a single length over each supplied rope, with no interruption, nor interchange, nor splice.

2.1.3 When a long length is specified (above 1000m), the rope assembly is normally made of several rope segments.

Ropes with a single length above 1000m and a weight above 20t will be specially considered by the Society, subject to adequate validation tests as relevant.

2.1.4 The method for joining yarns and the staggering of joins are to be defined.

2.1.5 If a coating, a lubricant or other additive is added during manufacturing, the information as per [1.3.1] is to include documentation of its persistence in a marine environment.

The methods of preparation and application, and the amount of product in the rope are to be specified.

2.1.6 A braided cover may include properly staggered strand interchanges.

2.2 Terminations

2.2.1 Ropes are normally provided with spliced terminations, to suit a thimble or similar device.

Manufacturing specifications and procedures are to define dimensions of eye, splicing method, splice arrangement, and each step of the manufacturing process.

2.2.2 The type of material (type of steel or other material), diameter, and groove geometry of thimble are to be defined, and the manufacturing of termination is to suit that geometry.

2.2.3 For parallel construction ropes, the arrangement and matching of subrope splices are to be defined:

In order to avoid that a damage (e.g. by cutting) of one subrope jeopardises the residual strength of the rope, each subrope should be tucked with itself after forming the eye of the splice (one-to-one splicing).

2.2.4 For short rope lengths, the relative orientation between the splices at each end is to be also defined, and kept identical between samples for prototype testing, for production testing, and for supplied items with a length less than 70 m.

2.2.5 The cover and particle ingress protection are to be restored over the splice area, to ensure continuity of protection.

An additional lining is to be provided in the bearing area of eye onto the thimble.

Eye and splice are to be further protected by a polyurethane coating.

2.2.6 Other termination systems would be given special consideration, when supported by extensive investigations of strength and durability.

2.3 Length of finished rope

2.3.1 The length of finished ropes is defined as a bedded-in length at a specified tension.

The bedded-in length L_{T0}, in m of supplied ropes at a tension T_0 is obtained as:

$L_{T0} = M / LD_{T0}$

where

M : The net mass of the rope, in kg, obtained by weighing, and corrected for ancillary weights and the additional mass of material in terminations,

LD_{T0} : The linear density (mass per unit length, MTex) of the rope in a bedded-in condition at a tension T_0 (in% of the MBS), obtained from the "linear-density test" specified in Sec 6, [3.1].

2.3.2 T_0 is a tension that is deemed representative of installed tension, so that the supply length L_{T0} is representative of the as-installed length of the rope.

Unless otherwise agreed by the Society, the tension T_0 is to be taken as follows:

- For polyester and high modulus materials, generally 20% of the rope MBS
- For polyamide, not less than 10% of the rope MBS.

Note 1: If a different tension or a different bedding-in/pre-stretching sequence is used, these conditions are to be indicated in the rope supply data sheet (see also Sec 6, [3.1] and Sec 7, [5.3]).

Note 2: Taking LD_0 (see App 1, [3.3]) in the above formula, the "length at reference tension" L_0 can be obtained (see also App 2, [1.7]). L_0 may be provided as information for the transportation and installation of the new rope.

Note 3: If another method than weighing is used to determine rope length, the Manufacturer will have to document the relation between the length of finished rope in the specified conditions and the length measurements performed during production.

2.3.3 The length of short ropes (such as rope samples or short segments of lines) may be taken as the length measured at a reference tension of 2% of the rope MBS (see Sec 5, [1.2.2]).

2.3.4 The length of finished ropes is to be within 1% of the specified length.

3 Marking

3.1 Name plate

3.1.1 A name plate is to be affixed at a convenient location at one end of each rope (be it a test sample or a part of the supply) and is to indicate, as a minimum, the following information (durably marked):

- manufacturer identification
- order and part number
- rope core material
- rope MBS
- date (month, year) of production.

The name plate is stamped with the relevant Society marking, at time of final inspection.

Section 5 Quality Control Activities

1 General

1.1 Inspection, testing and quality plan

1.1.1 Inspection and testing activities are to be conducted by the Manufacturer and surveyed by the Society, with the objectives of ensuring that:

- the prototype rope conforms to specifications, with any change made during the course of approval (in parameters that could affect quality of finished product) being duly reflected by modification of the specifications and procedures.
- produced ropes are in conformity with approved prototype.

1.1.2 A quality plan, covering all steps of manufacturing and inspection, is to be prepared by the Manufacturer and submitted to the Society for review, together with corresponding procedures.

Note 1: The qualification of operators, particularly those employed in rope splicing, is to be addressed within quality procedures.

Note 2: A quality plan usually covers a rope model and is reviewed accordingly.

1.1.3 Quality control check-lists and report forms are to be prepared by the Manufacturer, following a similar format than in OCIMF "Guidelines for the purchasing and testing of SPM hawsers" (duly modified to account for rope construction), or an equivalent practice.

1.2 Rope samples

1.2.1 Rope samples are to be taken from the production, at following rates:

- for prototype rope production, once in every length of continuous production
- for current production of ropes, once in the first length of continuous production, then, when the delivery exceeds 100t, at an agreed rate, not less than once every 70 t.

1.2.2 For each sample, a piece of rope is to be taken out, then set under a reference tension of 2% of the MBS, so that a length of about 2m (at the reference tension) can be marked, then cut.

Note 1: If, for large size ropes, the above tension cannot be achieved, a lower target may be set, not less than 100 kN, that is to be duly specified in inspection and test records (see also App 1).

1.2.3 Control measurements are to be taken, at the reference tension, of:

- rope outside diameter
- length and weight of rope sample
- weight of rope core of the sample
- cover thickness.

The linear density of rope and of rope core are to be calculated from the weight of sample and its length at the reference tension (see App 1, [3.3]).

Note 1: The rope diameter is generally given for information, and may be measured by an appropriate measuring device (e.g. a PI tape). Where diameter is deemed an important parameter, the effective maximum outside diameter should be measured with a calliper.

1.2.4 Samples are to be opened and inspected for conformity to design (number of components at each construction level, pitch or lay length of cover, subropes and strands).

1.2.5 Yarn re-testing and recalculation of rope strength are not required in the scope of quality control activities, and if performed as part of the Manufacturer's quality control procedures, are not to be used to advocate another breaking strength than the MBS given in rope specifications.

1.3 Rope testing

1.3.1 For the type approval of a rope, testing of prototype ropes is to be performed in accordance with the requirements of Sec 6.

1.3.2 For the verification of a rope already covered by a type approval certificate, a breaking strength test is to be performed on one rope sample taken from current production according to [1.2.1], following the same procedure as for prototype rope (see Sec 6, [2] and App 1, [3.2]).

The achieved tension at break is to be not less than the specified MBS and the rope core tenacity is to be not less than the tenacity specified for prototype ropes in Sec 6, [2.3].

Note 1: A measurement of the end of bedding-in stiffness is normally not required in the present test, not dispensing however from the bedding-in sequence, before testing to break.

Note 2: Test is not required for the production immediately following rope qualification tests.

Section 6 Rope Prototype Testing

1 General

1.1 Scope

1.1.1 Testing of a prototype rope is to be performed, with the objectives of verifying the breaking strength and other properties of the rope subject to certification.

1.1.2 Unless otherwise specified, the breaking strength test and the other tests aiming at verifying the rope properties are to be performed on full size samples. The tests qualify the prototype rope and other ropes that are of the same model (see Sec 1, [1.4.2]) and size.

1.1.3 When data are available from the previous qualification tests of one or several ropes of the same model but of a different size, to which a type approval has been issued by the Society, some of the tests need not be performed, as specified in Articles [3] to [5]. This is however subject to prior agreement by the Society, based on a review of all characteristics, including construction parameters of both ropes, and to the conditions specified in the present Section for each test.

Note 1: The Society may also give consideration, if relevant, to some tests performed for a different but similar model, provided it can be established as an evidence that results are not affected by the differences.

1.1.4 A plan for prototype testing is to be prepared and submitted to the Society for review, at time of the request for the type approval. Unless otherwise specified, the prototype testing plan is to include, as a minimum, the tests defined in Articles [2] to [6], as applicable, taking into account the accepted results of previously performed tests (see [1.1.3]).

In addition to the number of samples for the required tests, a spare rope should be available for possible retesting.

Note 1: Possible adjustments and further testing requirements are defined in Article [6] for tethers, hangers and other underwater offshore applications.

1.1.5 Rope samples for breaking strength test and cyclic loading endurance test are to be provided with the specified thimbles, or mounted on equivalent fittings (see App 1, [2.2]).

1.1.6 The condition (wetting) of sample(s) for each test is to be in accordance with the requirements of App 1, [2.2].

1.1.7 Tests are to be performed on a testing machine with adequate capacity, stroke, control and recording systems, for the test sequences defined in App 1. The calibration of testing machines is to be documented.

Tests may be performed either in the rope Manufacturer laboratory or in an independent laboratory.

1.1.8 When tests have been performed, a report of testing issued by the testing laboratory is to be provided for review. This report is to include identification of rope samples, all details of sample characteristics and mounting, with sketches and pictures, and the records of load-elongation measurements (see App 1, [2.3]).

2 Breaking strength test

2.1 General

2.1.1 For prototype testing, a breaking test (i.e. loading up to the actual breaking of rope) is to be performed on three samples, following the procedure as per App 1, [3.2].

2.2 Strength

2.2.1 The following acceptance criterion applies to the results of the three breaking strength tests defined in [2.1]:

- When all the measured tensions at rope breaking Tb, in kN, are not less than the specified MBS, the rope is deemed to have that MBS.
- When one of the measured Tb is below the specified MBS:
  - the result can be discarded only if the cause is identified, so that remedial action can be taken.
  - two additional tests have to be performed and, for the rope being deemed to have the specified MBS, both measured Tb are to be not less than that MBS.

2.2.2 If a test failure is due to the rope, the design of the ropes may need to be changed. When changes are found to be substantial (e.g. modification of fibre material or rope construction), a complete re-run of all prototype tests may be required.

2.2.3 Adjusting the MBS, upward or downward, from test results is not permitted.

Note 1: To define an adjusted MBS, a larger number of test results (5 minimum) should be available, from which a "characteristic breaking strength" could be obtained by suitable statistical derivation. Such procedure might be considered by the rope Manufacturer at time of rope design, using small size ropes or subropes, but is not required for the type approval of the rope.

2.3 Tenacity

2.3.1 For each breaking strength test defined in [2.1], the rope core tenacity T, in N/Tex, is obtained from:

$T = Tb / LDC_0$

where:

Tb : Tension at rope breaking, in kN

LDC_0 : Linear density of rope core at the reference tension of 2% of the MBS, in kTex (see [3.1] and App 1, [3.3], or Sec 5, [1.2.3] when applicable).

Note 1: When a significant amount of coating is applied in rope core, its mass can be deducted from LDC_0.

2.3.2 For ropes used in stationkeeping systems, the rope core tenacity obtained for each breaking strength test is to be not less than:

- 0,47 N/Tex for polyester ropes
- 1,30 N/Tex for HMPE ropes
- 0,90 N/Tex for aramid and polyarylate ropes
- 0,45 N/Tex for PA6 ropes (wet).

2.4 End-of bedding-in stiffness

2.4.1 For polyester ropes to be used in stationkeeping systems, the dynamic stiffness at end of bedding-in "Krebi" (see App 1, [3.2]) is to be obtained during each test and is to be between 18 and 28.

Note 1: Measurement of Krebi is for comparison (see App 2, [4.1]). Krebi is not meant to be a stiffness for utilisation in design.

For other materials and applications, where no specific range is defined, Krebi is to be measured for information, e.g. at time of other stiffness measurements.

3 Load-elongation measurements and response in torsion

3.1 Rope length

3.1.1 A "linear-density test" is to be performed at time of prototype testing, on one sample, following the procedure in App 1, [3.3].

This test provides load-elongation data, from which the linear density LD_{T0} of the rope in a bedded-in condition under a tension T_0, then the bedded-in length L_{T0} of supplied ropes at tension T_0 are obtained (see Sec 4, [2.3.1] and App 2, [1.7]).

3.1.2 When the rope is intended for a system where re-tensioning is not foreseen (see Sec 7, [5.1.4]), an "initial elongation test" is to be performed, following the procedure in App 1, [3.3.2], in order to evaluate the length of the line at the end of installation (see also App 2, [2.3.4]).

3.2 Quasi-static and dynamic axial stiffness

3.2.1 The load-elongation properties of rope under variable loading, i.e. the rope quasi-static and dynamic axial stiffness are to be obtained at time of prototype testing, according to the procedure specified in App 1, [4]

These tests need not be performed when data is available from the previous qualification tests of another rope with:

- a parallel construction with identical subropes, or
- subropes or rope core of the same model, and with a RBS (see App 1, [2.1.2]) or MBS between 50% and 150% of that previously tested.

3.2.2 These tests may be performed according to one of the three testing sequences described in App 1, [4.1] (i.e. within the breaking strength test, or on a separate subrope or rope sample).

Note 1: These tests are minimum tests, when the stiffness for ropes with a given fibre has been adequately characterised (see App 2, [3.1]).

3.2.3 Additional tests may have to be performed (on a subrope or a rope sample) if required, or when data for some particular service conditions are needed.

3.3 Response in torsion

3.3.1 For ropes that are not inherently torque neutral, the response in torsion is to be verified at time of prototype testing, by testing on one sample, following the applicable procedure and the criteria in ISO 18692-1 (See App 1, [6.1]).

3.3.2 This test needs not be performed when data is available from the previous qualification test of another rope with the same model of rope core and termination, and a MBS not less than 5000 kN.

4 Creep

4.1 General

4.1.1 In this Section, the term “creep” refers to the “secondary (steady state) creep”, i.e. the progressive, about proportional to elapsed time, non-recoverable increase of length of the fibre or rope under a constant tension that is exhibited by some materials, such as HMPE, under normal operating conditions (as to tension and temperature), as described in ISO 18692-3, Annex C.

Note 1: Same apply in Sec 7 and App 1, and elsewhere when quoted as “HMPE creep”.

4.2 HMPE ropes

4.2.1 For HMPE ropes, a test is to be performed according to the procedure specified in App 1, [3.4], at time of prototype testing, to calibrate long-term (secondary) rope creep rates with test data and model of fibre creep provided by the fibre Manufacturer.

For parallel construction ropes, this test may be performed on a subrope.

This test needs not be performed when data is available from the previous qualification test of another rope (or a subrope of it) with the same model of rope core, and a MBS not less than 3000 kN.

5 Endurance and durability

5.1 Cyclic loading endurance

5.1.1 For all rope core materials, the endurance under cyclic tension-tension loading is to be verified by testing on one sample.

Note 1: The purpose of this test is to confirm that the intended rope:

- is expected to have the appropriate endurance for the application
- will not suffer from premature failure due to inadequate design or manufacturing

This test needs not be performed when data is available from the previous qualification test of another rope, with the same model of rope (i.e. including terminations and cover), if the MBS of the rope to be qualified is between 50% and 200% of that of the tested rope.

5.1.2 The endurance test is to be performed according to the procedure specified in App 1, [5.1], for a load range LR between 40% and 50% of the rope MBS, with a mean load T_{mean} such that the maximum load during cycling T_{max} is between 52% and 55% of the rope MBS.

Note 1: Tmax is given by:

$T_{max} = T_{mean} + (LR / 2)$

The rope sample is to withstand cyclic loading for a number of cycles N to be taken, in function of the load range LR (in% of the specified MBS), as:

$N = 166 / LR^{5,05}$

Note 2: With the specified limits on LR, N will be between 5500 and 17000 cycles.

5.1.3 At the end of cycling, the rope is to be loaded to break. The achieved residual strength is to be not less than 80% of the MBS.

5.2 Axial compression fatigue

5.2.1 For ropes made of aramid or polyarylate fibres, axial compression fatigue is to be verified at time of prototype testing, by testing on one sample according to App 1, [5.2].

After low tension cycling, the rope is to be loaded to break. The residual strength is to be not less than 95% of the MBS.

This test needs not be performed when data is available from the previous qualification test of another rope with the same model of rope core, and a MBS not less than 3000 kN.

Note 1: This is not applicable to materials such as polyester or HMPE or polyamide.

5.3 Particle ingress protection

5.3.1 A test is to be performed according to the procedure and criteria specified in ISO 18692-1, as defined in App 1, [6.2], to verify the effectiveness of the particle ingress protection (see Sec 4, [1.5.3]).

This test needs not be performed when data is available from the previous qualification test of another rope with the same rope construction, particle ingress protection (with the same or a lower number of filter layers), and rope cover.

5.3.2 For shallow / intermediate water depths applications, in complement to the test described in [5.3.1], the efficiency of particle ingress protection is to be supported by biological investigations and validated by in-situ observations. See Sec 4, [1.5.4] and Sec 7, [3.3].

The biological investigations should be performed at an early stage of the project to investigate, for the intended site, the presence and size of propagules / internal biofouling of marine species that may penetrate in rope core and lead to the development of hard marine growth inside the rope.

In-situ observations are to be obtained by one of the following methods:

- prior to installation of the unit, by a dedicated study near installation site
- after installation, by the monitoring and inspection of the installed lines.

These observations are to be made on a sufficiently long and relevant period (one year minimum - preferably two) to allow for the development of marine growth.

At the end of this period, a rope segment is to be retrieved and submitted to:

- Visual and microscopic inspection, to detect the presence of hard marine growth inside the rope core
- Residual strength test, to identify a potential strength loss.

5.4 Other tests

5.4.1 When relevant (e.g. for innovative rope design, material or service conditions), other tests are to be performed according to agreed procedures.

6 Tethers, construction lines, and other underwater offshore applications

6.1 Testing

6.1.1 The testing requirements in Articles [2] to [5] generally apply to ropes intended for tethers, construction lines, tendons and other underwater offshore applications (see Sec 1, [1.2.2]), taking into account that:

- load levels in the linear density and in static and dynamic stiffness tests may be adjusted to suit the need of intended application
- the lower bound MBS, specified in [3] and [5] for the acceptance of previous tests for another rope size, will be considered on a case-by-case basis, depending on rope construction.

Note 1: A lower bound in the range of 1000 kN is generally applicable.

6.1.2 For some particular application, and/or a particular product or usage or service conditions, additional tests may be required. Testing methodology and acceptance criteria will be considered on a case-by-case basis.

Section 7 Ropes for Stationkeeping: Design and Operating Criteria

1 General

1.1 Scope

1.1.1 This Section defines the requirements applicable to the arrangement of fibre rope stationkeeping systems:

- In deepwaters, see Article [2]
- In shallow and intermediate water depths, see Article [3].

1.1.2 This Section also specifies the design (see Article [4]) and operating (see Article [5]) criteria specific to fibre rope stationkeeping systems, complementing and superseding the requirements of NR493.

2 Arrangement of stationkeeping systems in deepwaters

2.1 Lay-out

2.1.1 A deepwater fibre rope stationkeeping system typically includes, for each line:

- a top section, in general made of chain cable or wire rope (e.g. in mobile offshore drilling units), connected to the fairlead.
- the fibre rope section
- a bottom section, in general made of chain cable, attached to the anchor

Note 1: The system may be a taut leg system, with only a short bottom steel section, or a semi-taut or catenary system, where a longer bottom chain section is provided.

Note 2: The arrangement presented in the present article correspond to the well-proven current practice for deepwater installations. Other arrangement would require specific considerations, see Article [3].

2.1.2 Line top section

The line top section is to have a suitable length so that, with due allowance for the initial elongation of fibre rope under system pre-tension, further elongation over platform life, and creep where applicable (see [5.2] and App 2, [1.7]):

- the specified pre-tension can be maintained by adjustment of its length, keeping the upper end of fibre rope segment clear of platform fairleads
- the upper part of fibre rope segment is kept at a sufficient depth to avoid the development of hard marine growth (micro-organisms with a mineral shell) within the rope (generally at least 100m).

Note 1: Some extra length is generally provided for line hook-up and initial tensioning (see also App 2, [1.7]).

2.1.3 Fibre rope section

The fibre rope section is to be fully immersed at a sufficient depth (see [2.1.2]) and free-standing between termination points. It may be made of several segments, if needed for manufacturing or handling purpose (see also [5.3]).

2.1.4 Line bottom section

The line bottom section is to have a suitable length to keep the fibre rope clear of sea bottom in leeward lines, and thus avoid detrimental chaffing or ingress of soil particles (see also [4.2]).

As ropes are fitted with a particle ingress protection, this requirement does not apply to the damaged design conditions of the system (redundancy check) provided it can be ensured that sea bottom do not include hard soil areas and is free from other obstructions.

2.2 Torsional behaviour

2.2.1 A torque neutral construction is to be used in permanent systems where other line sections are made of chain or torque neutral spiral-strand wire ropes (see Sec 4, [1.4.2]).

Note 1: A parallel construction is most often used, that can be inherently torque neutral.

2.2.2 A torque-matched construction is to be used in permanent systems where other line sections are made of non-torque-neutral wire ropes, such as six-strand wire ropes, unless other arrangement is provided to avoid cyclic torsion at the interface (see Sec 4, [1.4.2]).

Note 1: In a non-balanced line, the cyclic variations of line tension would induce a cyclic torsion leading to degradation by fatigue of the wire rope near terminations.

2.3 Rope protection

2.3.1 The protective cover and particle ingress protection are to be in accordance with the requirements of Sec 4, [1.5.1] to Sec 4, [1.5.3].

Suitable procedures are to be considered to avoid contacts that may generate chafing or cutting of the rope protection (such as sharp edges or steel ropes) during installation and in-service.

The filter is to prevent the ingress of solid (soil) particles in case of contact with the sea floor (intended or accidental) during the installation of the system.

3 Arrangement of stationkeeping systems in intermediate / shallow waters

3.1 General

3.1.1 The requirements specified in Article [2] generally apply to floating units operated in intermediate / shallow water depths, subject to the specific considerations presented in this Article.

3.1.2 The present Article also applies to floating units operated in deepwaters, when the arrangement of the stationkeeping system deviates from the requirements of Article [2].

3.2 Lay-out

3.2.1 An intermediate / shallow water fibre rope mooring system generally includes the same 3 sections, as defined in [2.1.1].

3.2.2 Line top section

a) For these systems, a line top section made of chain cable should be generally provided following [2.1.2], except the requirement related to the minimum depth of fibre rope segment, that may not be achievable.

b) Alternatively, a fibre rope top section or a direct connection between fibre rope section and platform fairlead (i.e. no top section) may be considered, provided that:
   - Attachment points to the structure are continuously immersed over the life of the unit, through a fairlead or other connection device, allowing free rotations - in-plane and out-of-plane - between the end thimble and the unit (to avoid damage to eye by friction and to splice).
   - Fibre rope sections are in accordance with [3.2.3].
   - Means for line re-tensioning are provided elsewhere in the system or, if re-tensioning is not foreseen, the control of line slackening over the life of the structure (see App 2, [1.7]) is addressed following [5.2.4].

3.2.3 Fibre rope section

The requirements specified in [2.1.3] apply.

Buoys may be provided at segments ends, in order to avoid seabed contact. Alternatively, some segments may be provided with distributed buoyancy elements.

When integrated to the rope construction, buoyancy elements are to be installed over the rope cover, in order not to jeopardise the continuity of the rope protection.

Note 1: A second rope cover and/or lashings/sewing may be used to fix the buoyancy elements to the rope.

For the fibre rope segments located in the biofouling (marine growth) development zone, the following apply:

- The additional mass and drag induced by the marine growth on the rope are to be considered in the analyses (see NI691, Sec 2, [5.1.6]).
- The rope protection is to be in accordance with the requirements of [3.3.1] and [3.3.2].

3.2.4 Line bottom section

The bottom section may be equipped with additional weight to avoid anchor uplift, when relevant.

A buoy may be provided at the connection point between fibre rope section and line bottom section. Nevertheless, avoiding repeated contact of fibre rope lower segment with the sea bottom may not be achievable: in such case, the considerations given in [3.3.3] apply.

3.3 Rope protection

3.3.1 The rope is to be protected against the penetration of propagules / internal biofouling that may lead to the development of hard marine growth. The particle ingress protection (see Sec 4, [1.5.3]) is expected to have a beneficial effect for this purpose. However, its efficiency for the intended site is to be supported by biological investigations and validated by in-situ observations (see Sec 6, [5.3.2]).

Note 1: Rope coating may be used to provide additional protection against biofouling / particle ingress.

3.3.2 The means to mitigate UV degradation of rope top segment are to be documented.

3.3.3 When dynamic seabed contact cannot be avoided, or for other particular service conditions, the adequacy of rope design and protection for such conditions is to be supported by further laboratory testing and/or in-situ validation.

4 Design criteria (in-place system)

4.1 Strength (maximum tension)

4.1.1 The design criteria for the strength of line components, i.e. the safety factors for each of the design condition examined, are to be in accordance with the requirements of NR493, Sec 3.

The reference strength is the specified MBS, as verified by the testing procedure in App 1, [3.2].

Note 1: For polyamide, the MBS is a wet breaking strength.

4.1.2 For fibre ropes certified according to this Rule Note, other than polyester and HMPE ropes, the minimum values of safety factors are to be increased in the rope itself (i.e. not including other parts of the line) by 10%. For polyester and HMPE, no increase needs to be considered.

4.2 Minimum tension in leeward line

4.2.1 The minimum tension in leeward lines is to be evaluated.

4.2.2 For ropes made of materials that are sensitive to compression failure (such as aramid and polyarylate), and when the ropes have demonstrated axial compression fatigue performance, according to Sec 6, [5.2], a minimum tension of 2% of the MBS including dynamics is to be maintained in the rope, for all design conditions of the system. This is however not required for the “redundancy check” (damaged) design conditions.

4.2.3 For ropes made of materials that are not deemed sensitive to axial compression failure (such as polyester, HMPE and polyamide) and for permanent systems, a positive tension is to be maintained, in principle, in the fibre rope under operating and design conditions, not including however the “redundancy” check (damaged) design conditions.

This is intended to avoid complete slackening of the line, then contact of the rope with sea bottom (see [2.1.4]) and risks of snap loads in the bottom line section, particularly when occurring under dynamic conditions.

If this is not achievable given system geometry, considerations should be made for adequate protection or other mitigating provisions (see [3.3.3]).

4.3 Endurance under cyclic loading

4.3.1 The fatigue life of the lines under cyclic tension-tension loading should be evaluated, in accordance with the requirements of NR493, Sec 3, [8] and NR493, Sec 3, [9.4]

Note 1: Attention is drawn to the fact that, in a fibre rope mooring, the adjacent steel components will generally have a fatigue strength significantly lower than the one of the rope itself.

4.3.2 For long-lay polyester ropes and HMPE ropes meeting all relevant requirements of this Rule Note, the “Polyester” T-N curve from NR493, Sec 3, [9.4.5] is to be considered.

Note 1: With respect to the data from the Rope Durability project on polyester ropes (OTC 17510-2005), this T-N curve accounts - conservatively - for scale effects that have been observed at medium load ranges. For HMPE, it is proposed as a conservative lower bound for this evaluation.

Note 2: For these materials, the endurance test in Sec 6, [5.1] is intended as a global verification test of rope assembly.

4.3.3 For other materials, having a rope endurance validated by the cyclic loading endurance test in Sec 6, [5.1], the T-N curve for spiral strand wire ropes may be considered (see NR493, Sec 3, [9.4.4]).

4.4 Creep

4.4.1 For HMPE, a prediction is to be made of the long-term creep of the rope. This prediction is to be based on:

- fibre data of creep rates (see Sec 3, [1.3.3])
- correlation between fibre and rope obtained from prototype testing (see Sec 6, [4])
- long-term rope tension data (an evaluation method is outlined in A.14.4 of ISO 19901-7).

Note 1: Creep is both load and temperature dependent. Then, only the most critical section (usually the top part) needs to be evaluated with respect to the allowable creep. An evaluation for the whole length could also be made to indicate the expected total creep elongation, where needed.

4.4.2 This prediction aims at providing an evaluation of the expected creep per year, thus of the expected lifetime of rope (for this criterion) with respect to the intended service life, taking into account the allowable creep elongation for a section of the rope, that is defined as the smaller of:

- the extension at which the strength of the rope is still at least 95% of the original specified MBS
- 10% of the installed length.

Note 1: For a “very low creep” grade fibre, the criteria on elongation would have to be reconsidered.

5 Installation, Operation and Inspection

5.1 Installation

5.1.1 The installation of the mooring system is to be performed according to dedicated procedures, in order to avoid torsion and damage by over-bending on obstacles, chafing or cutting, as well as contamination by solid or liquid projections.

Guidance on rope handling care, identification of damages and repair may be found in Annex C of ISO 18692-1.

Lines are to be generally deployed under a low tension, with a suitable minimum tension being ensured to avoid risk of damage by local over-bending in a free-span, and are to be generally kept clear of sea bottom.

Seizing of line, or seizing of ancillary installation devices on line, is to be performed by soft rope seizing only. The accumulation of twist in line is to be avoided.

5.1.2 Ropes being fitted with a particle ingress protection may be pre-laid on bottom, provided it is ensured that sea bottom do not include hard soil areas and is free from other obstructions.

Note 1: A rope without particle ingress protection that has been dropped or laid on the seafloor is not to be used as a long-term component of a permanent mooring system.

5.1.3 For materials that are sensitive to compression failure, pre-deployed lines, if not laid on bottom, are to be maintained under tension, in a way that is preventing high cyclic straining (by bending or torsion) at rope ends. A minimum mean tension of 2% of the MBS may be considered, provided that the rope has not been pre-stretched before.

5.1.4 The tensioning of lines is to be performed in such a way that a stable pre-tension, consistent with mooring design, can be obtained.

For this purpose, as a rule, a pre-stretching of ropes is to be performed consisting, within the hook-up sequence, in appropriate hold load or cycling.

Note 1: Pre-streching results in the development of both permanent and delayed (visco-elastic) elongations. To be efficient, it should thus include, after the application of a higher tension, the releasing to the target line pre-tension without significant unloading before line hook-up (otherwise, its benefit is partly lost).

Otherwise, the tensions after installation (line hook-up) should be high enough above the design pre-tension to account for relaxation (see App 2, [1.7]).

In any case, the tension in rope during tensioning (and for anchor testing, if applicable) is not to exceed 50% of the rope MBS.

5.2 Operations

5.2.1 During operation, care should be taken to avoid risks of damage to the rope, such as cutting by a steel wire rope.

5.2.2 The stationkeeping system is to be fitted with a system allowing to monitor line tensions periodically all along the design life of the unit.

5.2.3 As a consequence of fibre ropes bedding-in, lines tend to slacken during operation, primarily in the first months after installation (see App 2, [1.7]).

In principle, means are to be available to re-tension the lines, whenever needed, to design pretensions.

5.2.4 When re-tensioning is not foreseen (e.g. for MRE units):

- the design assessment of the stationkeeping system is to cover the progressive drop of pre-tension due to line slackening (see App 2, [1.7], App 2, [2.3.4] and App 2, [5.3.5])
- the initial condition of the system is to be documented by a test (Initial elongation test - see Sec 6, [3.2.3])

5.3 In-service inspection of ropes

5.3.1 For permanent offshore units, the monitoring of rope condition is to be performed by the operator and is normally achieved through “visual” inspection (by ROV). However, recovery, then inspection and testing of a recovered rope section, may be necessary in some circumstances (e.g. after a significant accidental event). Short rope segments may be provided (at the top of lines) for this purpose.

5.3.2 For mobile offshore units, the lines are to be subject to comprehensive inspection when recovered between platform moves, with attention to damage by cutting, chaffing, or contact with sea bottom. Whenever needed a section is to be cut for inspection and testing, at one or the other end, unless short rope segments have been provided to that effect.

5.3.3 When classification notation **POSA** is assigned, inspections quoted in [5.3.1] and [5.3.2] are to be integrated to the program of class renewal survey, as per the requirements of NR493, Sec 2.

5.4 Creep monitoring

5.4.1 For HMPE, where relevant depending on the application and fibre grade selected, creep in a top section of the rope is to be monitored, through preset marking or other appropriate method.

The maximum allowable creep elongation defined in [4.4] is not to be exceeded.

Other criteria (e.g. a maximum service time) specified by fibre or rope manufacturer(s) are also to be met.

Appendix 1 Rope Testing

1 Application

1.1 General

1.1.1 This Appendix defines the procedures for the testing of fibre ropes following the provisions of Sec 6. These procedures are applicable when referenced in Sec 6, where the relevant acceptance criteria are specified.

Note 1: The procedures herein are in line with those of ISO 18692 series of standards (see Sec 1, [1.4.2]).

Other testing procedures may be considered if, in the opinion of the Society, they can be deemed equivalent to those specified in this Appendix, or more appropriate for a particular product or usage or service conditions.

Any additional tests, when required, are to be performed following previously agreed procedure.

2 Testing conditions

2.1 Testing equipment

2.1.1 The testing machine is to have adequate capacity and stroke for the intended tests, and is to be fitted with a control system such that applied load (or cross-head movement) is continuously monitored, at any time during the testing sequence (i.e. during both loading and unloading).

For cyclic loadings, the triggering signal is to be - or as close as possible to - a harmonic sinusoidal signal with a period between 10s and 30s (unless otherwise specified). The amplitude and/or period of the first 10 cycles in a sequence may slightly deviate from this range, but the period is not to exceed 60s in principle.

2.1.2 In the testing steps defined in this Appendix, loads are defined as a percentage of the specified rope MBS.

For testing on subropes of a parallel construction rope, the same percentage of a reference strength RBS, in kN, is to be taken, with RBS defined as follows (see [2.2.1], Note 2):

RBS = MBS / n

where

n : Number of subropes in rope core.

Note 1: During ramp loadings (both increase -including for breaking or decrease) the rate of loading, specified in% of the MBS per minute, may be obtained either as a tension rate or as the equivalent cross head velocity.

Note 2: For stiffness measurements, cyclic loading, defined in this Appendix as load ranges, may be also applied as the equivalent imposed displacement, provided mean load can be kept constant over the duration of cycling.

2.2 Condition of rope samples

2.2.1 Samples

Rope samples (or subrope samples, when relevant) are to be taken from a length of the rope to be qualified.

The terminations of rope samples for break tests, cyclic loading endurance, torque and axial compression tests are to be same, in all respects, as those for intended supply, and are to be mounted on the specified thimbles, or on fittings with same radius and groove shape, and same type of material as the specified fittings.

For other tests, terminations with different dimensions may be used. In such case, rope samples are to be selected and mounted with the correct terminations with respect to the test to be performed.

Note 1: As an exception, polyurethane coating (see Sec 4, [2.2.5]) may be omitted for test samples.

Note 2: For parallel construction ropes some of the tests can be performed on subropes when – and only when - specified in the following articles. In such case, due caution is to be exerted to avoid any torsion in the subrope sample, and to preserve the lay length of subrope, particularly for laid constructions.

2.2.2 Sample condition

The conditions of rope samples to be considered for prototype testing are provided in Tab 1.

Note 1: The soaking times presented in Tab 1 are to be considered as minimum duration for the preparation of samples for prototype testing.

Table 1 : Sample conditions

<table>
<tr><td rowspan="2">Tests</td><td colspan="4">Material</td></tr>
<tr><td>Polyester</td><td>HMPE</td><td>Aramid / Polyarylate</td><td>Polyamide</td></tr>
<tr><td>Linear density</td><td>Dry</td><td>Dry</td><td>Dry</td><td>Dry</td></tr>
<tr><td>Breaking strength</td><td>Wet (4h soaking time)</td><td>Wet (4h soaking time)</td><td>Wet (4h soaking time)</td><td rowspan="3">• Wet (24h soaking time before the test), or
• Wet (4h soaking time + immersion or continuous watering during the test)</td></tr>
<tr><td>Stiffness</td><td rowspan="2">• Wet (4h soaking time), or
• Dry</td><td rowspan="2">• Wet (4h soaking time), or
• Dry</td><td rowspan="2">• Wet (4h soaking time), or
• Dry</td></tr>
<tr><td>Torque measurement</td></tr>
<tr><td>Endurance</td><td colspan="4">Wet (4h soaking time + immersion or continuous watering during the test)</td></tr>
<tr><td>Axial compression fatigue</td><td>–</td><td>–</td><td>Wet (4h soaking time + immersion or continuous watering during the test)</td><td>–</td></tr>
<tr><td>Creep</td><td>–</td><td>Wet (4h soaking time + temperature-controlled conditions)</td><td>–</td><td>–</td></tr>
</table>

2.2.3 Cover condition

For the breaking test of prototype ropes and other gauge length elongation measurements, the cover is to be cut for the marking of rope core (measurement by video image processing) or for fixing the extensometer.

Note 1: The cutting of cover may be omitted for the breaking strength test of a sample for current production.

For the linear density test, at the contrary, the marking is to be made on the cover, and the cover is to be fastened to the rope core, so as to avoid any slippage between core and cover.

For the cyclic loading endurance test and axial compression fatigue test, the cover is to be left intact.

2.3 Recording

2.3.1 The ambient conditions (such as humidity, water or air temperature) during each test are to be recorded.

The cross-head elongation and rope tension are to be continuously recorded over each test. The recording of rope tension is to be performed by a properly calibrated strain gauge system.

For stiffness measurements and HMPE creep tests, the elongation over a gauge length of 1 m minimum set at middle of the test rope, clear from terminations, is to be recorded by a system of adequate sensitivity, taking into account rope material and relevant testing sequences (see [4]). The gauge elongation and load are to be continuously recorded.

Note 1: The cross-head elongation provides an overview of the rope behaviour along each test, but can only give qualitative indications on stiffness. Gauge elongation measurements, by eliminating the effect of splice and eye, provide quantitative data that are representative of the response of a long line.

Note 2: For the cyclic loading endurance test and axial compression fatigue test, no extensometer is to be fixed to the sample, to avoid any damage to the rope that could bias the test result.

2.3.2 As a minimum, the gauge length and elongation are to be continuously recorded as follows, during the breaking test and stiffness measurement test defined in [3.2] and [4]:

- over the initial loading and unloading of rope sample (see [3.2.1], a))
- over the last bedding-in cycles (at least three full cycles) for the measurement of the dynamic stiffness at end of bedding-in
- over the full three cycles of the “quasi-static” stiffness test (load and elongation versus time)
- over the last cycles (at least three full cycles) of each mean load step of the dynamic stiffness test, for the measurement of the dynamic stiffness.

The reference gauge length for the calculation of elongation of the rope (i.e. strain) is to be reported.

Any deviation of the specified test conditions are to be duly recorded.

Note 1: The sampling rate may be adjusted according to each sequence e.g., as a minimum, one per 30 s during load ramps, one per minute during a load holding plateau, one per second during cycling for dynamic stiffness.

Note 2: In theory, the variation of gauge length should be normalised by either the gauge length at the start of a sequence or an average gauge length, depending on the test.

3 Testing sequences

3.1 General

3.1.1 Each test generally includes the following three phases, unless otherwise specified for a particular test:

- phase 1: initial loading and bedding-in
- phase 2: cycling
- phase 3: loading to break.

For each test, the steps of the different phases are detailed in [3.2] to [3.4], [4] and [5].

Note 1: During phase 1, if the sequence needs to be interrupted, e.g. to reset fixed end or gauge length measurement system, during initial loading or bedding-in, the corresponding step shall be repeated (including the full number of bedding-in cycles).

3.2 Breaking strength test

3.2.1 A breaking strength test is to include the following steps:

a) Phase 1:
   - mount the sample and load to 2% of the rope MBS, for marking and for setting of extensometer
   - increase tension to 50% of the MBS, in approximately 5 min and hold load for 30 min
   - unload to 10% of the MBS, at about same rate (approximately 10% / minute)
   - bedding-in: perform cyclic loading (see [2.1]), between 10% and 30% of the MBS, for 100 cycles
   - for polyester ropes only, measure the dynamic stiffness at end-of-bedding-in (Krebi) in the same way as in [4.5.2].

b) Phase 2:
   - when the stiffness measurements are performed as part of breaking strength test, the testing sequences presented in [4.3] or [4.4] are to be applied
   - otherwise this phase is skipped.

c) Phase 3:
   - unload the sample to 2% of the MBS
   - load to break, at a rate of about 20% of the MBS / min
   - record the residual breaking strength of the rope.

3.3 Linear density and initial elongation tests

3.3.1 Linear density test

The linear density of the rope at the tension T_0, specified in Sec 6, [3.1], is to be obtained as follows, without interruption:

a) Phase 1:
   - mount the sample, load to 2% of the rope MBS, and mark a length LR_0 of about 2m
   - increase tension to 20% of the MBS in approximately 5 min
   - perform cyclic loading between 0,75 T_0 and 1,25 T_0, for 100 cycles
   - at end of cycling, hold load at T_0 and measure the length LR_{T0} between marks.

b) Phase 2:
   - unload to 2% of the MBS, and measure the length LR_2 between marks (for information).

c) No phase 3, but:
   - Cut the sample at the marks, and weigh it:

     The linear density LD_{T0}, in MTex, is obtained as follows:

     $LD_{T0} = MR / LR_{T0}$

     where:

     MR : Mass of the cut sample, in kg

     LR_{T0} : Length, in m, measured in Phase 1
   - Separate cover and weigh the rope core:

     The linear density LDC_0, in MTex, of rope core at reference load is then obtained as follows:

     $LDC_0 = MC / LR_0$

     where

     MC : Mass of rope core of the cut sample, in kg

Note 1: Linear densities LD_0 and LD_2 are obtained in the same way as LD_{T0}, from LR_0 and LR_2. These data are for information.

Note 2: If a lower reference load than 2% of the MBS is used in samples for quality control (see note in Sec 5, [1.2.1]), the lengths LR_0 and LR_2 are to be measured at that tension.

3.3.2 Initial elongation test

When relevant (see Sec 6, [3.1.2]), a test is to be performed on a new unbedded-in subrope or rope sample, with the following steps:

- mount the sample and load to 2% of the rope MBS, for marking and for setting of the extensometer
- increase the tension following a loading sequence and with durations that are representative of intended installation conditions, until the specified installed tension is achieved
- unload the sample.

Tension and elongation are to be continuously recorded. The gauge elongation between reference tension at start (2% MBS) and the installed tension is to be reported.

3.4 Creep test

3.4.1 For HMPE, the following test is to be performed, on one subrope sample, to calibrate the creep rate of the rope with fibre data:

a) Phase 1:
   - mount the sample and load to 2% of the RBS (see [2.2.1]), for marking and for setting of extensometer
   - increase tension to 50% of the RBS, in approximately 5 min and hold load for 30 min
   - unload to 20% of the RBS, at about same rate (approximately 10% of the RBS / minute)
   - cycle between 10% and 30% of the RBS and for a minimum of 300 cycles.

b) Phase 2:
   - select a tension T (typically in the range of 33 to 50% of the RBS)
   - load the sample to the preselected tension T and hold load for a minimum of 7 days
   - unload the sample.

c) No phase 3.

3.4.2 The testing temperature is not to exceed 25°C and is to be kept as constant as possible over the test duration (no more than 5°C range)

3.4.3 The creep rate is obtained by fitting of the gauge elongation versus time (in natural scale) over the end of the test (e.g. last one or two days), or by the observation of the stabilization of creep rate with time.

Note 1: In case of a "very low creep" grade (see Sec 7, [4.4.2]), a different procedure may be used.

4 Stiffness tests and measurement

4.1 Testing conditions

4.1.1 The measurements of the quasi-static and dynamic stiffness on prototype rope(s) can be achieved in different ways, as follows:

- quasi-static and dynamic stiffness measurements are performed on a separate sample than those for breaking strength test (case 1)
- quasi-static and dynamic stiffness measurements are performed during the phase 2 of one breaking strength test (case 2)
- quasi-static and dynamic stiffness measurements are distributed over the three breaking strength tests and performed during phase 2 of each test (case 3).

The testing sequences for each of those 3 cases are detailed in [4.2] to [4.4].

4.1.2 Specific conditions - Polyamide

For polyamide ropes, these tests are to be performed on a separate sample (case 1), with the same fully wetted conditions as for breaking strength tests.

The same (mild) bedding-in sequence as for phase 1 of the Linear Density test (see [3.3]) is to be used.

Note: cases 2 and 3 in [4.3] and [4.4] are not applicable.

4.2 Testing sequence – Case 1

4.2.1 The measurements are to include, as a minimum, the following steps when performed on a separate sample than those for breaking strength tests:

a) phase 1: same as for phase 1 for breaking strength test: see [3.2].

   For materials other than polyester, Krebi is to be measured for information.

b) phase 2-QS: quasi-static stiffness test

For the measurement of the quasi-static stiffness, phase 2-QS includes three cycles, without interruption, between 10% and 30% of the rope MBS, with the following steps for each cycle:

- load slowly the rope from 10% to 30%, at a rate between 3% and 10% of the MBS / min
- hold load at 30% until 30 min after the start of a)
- unload slowly the rope from 30% to 10%, at a rate as in a)
- hold load at 10% until 30 min after the start of c).

c) phase 2-D: dynamic stiffness test, for a minimum of three mean loads.

For the measurements of dynamic stiffness, phase 2-D includes, as a minimum, cycling (see [2.1]) with a load range of 10% (i.e. ± 5%) and a minimum of 100 cycles around each of the following mean loads, in ascending order:

- 25% of the MBS
- 35% of the MBS
- 45% of the MBS.

d) no phase 3.

4.2.2 For parallel construction ropes, the stiffness testing and measurements may be performed on a subrope. In this case, the reference breaking strength (RBS) as defined in [2.1] is to be considered in the testing sequences defined in [4.2.1],instead of the MBS.

4.3 Testing sequence - Case 2

4.3.1 The measurements are to include, as a minimum, the following steps when performed as the phase 2 of one breaking strength test:

- phase 2-QS: quasi-static stiffness test, as per [4.2]
- phase 2-D: dynamic stiffness test, for a minimum of three mean loads, as per [4.2].

4.4 Testing sequence - Case 3

4.4.1 The measurements are to include, as a minimum, the following steps when distributed over the three breaking strength tests and performed as the phase 2 of those tests:

a) Sample n°1:

- phase 2-QS: quasi-static stiffness test, as per [4.2]
- phase 2-D: dynamic stiffness test following [4.2], for the 25% mean load and for a minimum of 100 cycles.

b) Sample n°2:

- phase 2-D: dynamic stiffness test following [4.2], for the 35% mean load and for a minimum of 200 cycles.

c) Sample n°3:

- phase 2-D: dynamic stiffness test following [4.2], for the 45% mean load and for a minimum of 300 cycles.

4.5 Recording

4.5.1 Quasi-static stiffness test

The load and elongation are to be continuously recorded as a function of time. The quasi-static stiffness is to be taken as a secant stiffness between the end points of the last cycle:

$Krs = (T_2 - T_1) / (X_2 - X_1)$

where:

T_1, T_2 : Tensions during the plateau of the two last 1/2 cycles, in % of the MBS

X_1, X_2 : Elongations at the end of these 1/2 cycles, in % of gauge length.

Note 1: Values for design are to be obtained by extrapolation, following the procedure in App 2, [2.2].

4.5.2 Dynamic stiffness test

The load is to be continuously recorded as function of elongation, at least over the last cycles (minimum three full cycles) of each step. The dynamic stiffness Krd for the conditions of that step (mean-load, load range, period) may be obtained by linear regression of the tension versus elongation over these last cycles.

Note 1: Subject to suitable sampling intervals and accuracy of elongation measurements, the dynamic stiffness may be also obtained from maximum and minimum loads and elongations over the last cycle as in [4.5.1] (not applicable to polyamide).

5 Endurance tests

5.1 Cyclic loading endurance test

5.1.1 A cyclic loading (tension-tension) endurance test includes the following steps:

a) Phase 1:
- mount the sample and load to 2% of the rope MBS
- increase tension to 50% of the MBS, in approximately 5 min and hold load for 30 min
- unload to 30% of the MBS, at about same rate (approximately 10% / minute).

b) Phase 2:

Cycle for the specified mean load and load range, as per Sec 6, [5.1], with a period not exceeding 100s in principle, until the specified number of cycle is achieved.

c) Phase 3:
- unload the sample to 2% of the MBS
- load to break, at a rate of about 20% of the MBS / min
- record the residual breaking strength of the rope.

5.2 Axial compression fatigue

5.2.1 For aramid and polyarylate, the axial compression fatigue test includes the following steps:

a) Phase 1:
- mount the sample and load to 2% of the rope MBS
- increase tension to 50% of the MBS, in approximately 5 min and hold load for 30 min
- unload to 20% of the MBS, at about same rate (approximately 10% / minute).

b) Phase 2:
- cycle between 10% and 30% of the MBS for a minimum of 300 cycles
- cycle between 1% and 20% of the MBS for a minimum of 2000 cycles.

c) Phase 3:
- unload the sample to 2% of the MBS
- load to break, at a rate of about 20% of the MBS / min
- record the residual breaking strength of the rope.

6 Other tests

6.1 Response in torsion

6.1.1 The assessment of the response in torsion of a rope, when needed, is to be performed according to the method and the criteria specified in ISO 18692-1.

Note 1: Specific testing procedures apply to “torque-neutral” and to “torque-balanced” ropes.

6.2 Particle ingress protection

6.2.1 The assessment of the efficiency of the particle ingress protection system is to be performed according to the method specified in ISO 18692-1. The criteria specified in Sec 4, [1.5.3] are to be met.

Appendix 2 Guidance on Load-Elongation Properties of Fibre Ropes

1 General

1.1 Application

1.1.1 The present Appendix gives guidance on the load-elongation properties of fibre ropes, and their modelling in mooring analysis.

1.2 Fibre ropes

1.2.1 The load-elongation properties of fibre ropes are rather complex to evaluate and specify, in comparison with the linear elastic behaviour of equivalent steel components. The model presented in this Appendix defines rope properties for engineering and analysis of a fibre rope mooring system, in a consistent manner with the testing procedures specified in this Rule Note.

Note 1: Due to the nature of constituent material (a complex assembly of long chains of organic molecules), fibres and fibre ropes exhibit a visco-elasto-plastic behaviour (i.e. non-linear and time dependent) that cannot be reduced to a linear (nor a non-linear) load-elongation “characteristic”.

1.3 Bedding-in

1.3.1 A particularly important aspect, quite specific to fibre ropes, is the modification of the properties of a rope during the first loading(s) and during the early stages of rope service. This process, called “bedding-in”, involves changes at both a macroscopic level (e.g. compaction of the structure) and, primarily, at a molecular level within fibres. Bedding-in results in an essentially permanent (non-recoverable) elongation with respect to the rope initial length at time of manufacturing (unless the rope is returned to a loose condition for a substantial time: what normally does not happen in an operating mooring system), and in some (limited) changes in the rheological properties.

1.3.2 Most of the bedding-in happens during the initial loading, at time of installation, or quickly after. Rope pre-stretching during installation accelerate this process. Further bedding-in occurs with the variations of mean tension and the cyclic loading imposed by metocean or other (e.g. re-tensioning) actions.

Note 1: In the testing procedures in App 1, two levels of bedding-in are specified:

- a higher level for the strength tests and for the stiffness measurements
- a lower level for the linear density test and for polyamide stiffness tests: see App 1, [4.1.2].

1.4 Rope mean elongation

1.4.1 The mean elongation of a rope may be defined as the combination of the following contributions:

- a load dependent incremental permanent (non-recoverable) elongation, happening when the tension in rope exceeds the maximum tension achieved in a previous storm or other event
- a time dependent visco-elastic term tending, under stationary conditions, toward a stabilisation of the rope elongation (in tests, depending on end conditions and previous history this term can be creep or recovery or relaxation or inverse relaxation)
- for HMPE, the secondary (non recoverable) creep. See Sec 6, [4].

1.5 Stiffness

1.5.1 Under the assumption of a linear elastic behaviour around a given mean condition, the load-elongation relation of a line subject to a varying load is given by the following formula:

$\Delta F = Ku\ \varepsilon$

where:

$\varepsilon = \Delta L / L$

ΔF : Variation of tension in a rope segment of length L, under a variation of length ΔL

L : Bedded-in length of rope segment under tension T_0

Ku : Spring constant of a unit length of the line.

Note 1: Ku is sometimes noted EA.

Ku is generally normalised with respect to the rope MBS or rope core linear density m. The load-elongation relation is then given by the following formulae:

$\Delta F / MBS = Kr\ \varepsilon$

$\Delta F / m = (E / p)\ \varepsilon$

where:

Kr : Non dimensional reduced stiffness

E / ρ : Modulus, in tenacity unit (N / tex).

1.6 Mechanical Model

1.6.1 Polyester ropes

For polyester ropes, a practical engineering model has been developed and is presented in Articles [2], [3] and [4.1].

Note 1: This approach is based on [1.8.3] and on earlier works (see [1.8.1] and [1.8.2]).

1.6.2 High modulus ropes

For high modulus ropes, the same model of quasi-static and dynamic stiffness can be applied. See [2], [3] and [4.2].

Note 1: Tests have generally confirmed the applicability of this model (see [1.8.4]), but less calibration data are available.

1.6.3 Polyamide ropes

For polyamide ropes, the load-elongation properties are more complex than for polyester and high modulus ropes. A different model, built on the same basis, is given in Article [5], as guidance.

1.6.4 The elongation of a rope working as a line in a stationkeeping system may be written as the sum of three terms, related to the time scale of actions:

- elongation under permanent load (line pre-tension), see [1.7] and [2.3]
- variations of elongation due to changing weather conditions, herein quoted as the “quasi-static” response, see Article [2]
- rapidly varying (cyclic) loading (or imposed cyclic displacements), i.e. a time scale ranging from seconds (e.g. wave induced motions, higher frequency actions from wind turbine in operation) to minutes (e.g. slow drift motions or vortex induced motions, around the natural period of the system): this is modelled by the “dynamic stiffness” (see Article [3]).

Note 1: This separation is also matching the typical steps of a mooring analysis:

- set-up of the model
- static response to mean loads
- low and wave frequency response.

1.7 Line length

1.7.1 The length of finished ropes L_{T0} is defined as a bedded-in length at a specified tension: see Sec 4, [2.3].

L_{T0} is herein taken as the reference length for the evaluation of rope elongation.

Note 1: A loading sequence that is deemed representative of a typical installation condition of a stationkeeping system is specified in the testing procedure (the “linear density test”, see App 1, [3.3]), so that this bedded-in length is representative of the as-installed length of the ropes at the tension T_0.

Note 2: For the purpose of installation planning, the “length at reference tension” L_0 (see Sec 4, [2.3.1]) can be deemed representative of the length of the line once deployed.

1.7.2 The length of the rope under permanent load (line pre-tension), i.e. its elongation X_{pt} with respect to L_{T0}, and the pre-tension T_{pt} itself, both depend on the examined condition and on tension history since installation, as detailed in [2.3] and [5.3].

Note 1: This length tends to increase with time, by the accumulation of permanent elongation e.g. after an important storm, also by creep for HMPE. This will result in a progressive drop of line pre-tension unless re-tensioning is performed.

1.7.3 The fully bedded-in conditions of the rope (typically after one or two storm seasons) are applicable to the occurrence of extreme and fatigue (design) conditions, and are noted herein as “Long-term conditions” (see [2.3.2] or [5.3.3]).

The conditions of the system after installation, that may need to be considered for possible sudden storm occurrence (e.g. the first hurricane of the season), are noted herein as “early life conditions” (see [2.3.3] or [5.3.4]).

1.7.4 In Articles [2] to [5]:

- Elongations are expressed in % of L_{T0} (unless otherwise noted, see [5.4.3])
- Tensions are expressed in % of the rope MBS.

1.8 Bibliography

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1.8.2 OTC 10779 - 1999 - Bosman R.L.M. and Hooker J. - The Elastic Modulus Characteristics of Polyester Ropes.

1.8.3 OMAE 57136 - 2008 - François M. and Davies P. - Characterisation of Polyester Mooring Lines.

1.8.4 OTC 20846 - 2010 - François M., Davies P., Grosjean F. and Legerstee F. - Modelling Fiber Rope load-elongation properties: Polyester and other fibers.

1.8.5 Ocean Engineering - 2024 - François M. and Davies P. - An empirical model to predict elongation of polyamide mooring lines - OE-D-23-01974.

2 Quasi-static response

2.1 General

2.1.1 The quasi-static response addresses the variations of rope elongation at a very slow rate that are induced by the variations (increase or decrease, in "windward" or "leeward" lines, respectively) of the mean tension in each line, under the effect of changing weather conditions (such as the build-up and decay of a storm or the occurrence of a loop current), i.e. a time scale of several hours or days.

Note 1: This does not include the "slow-drift" motions, for which the dynamic stiffness is applicable (see Article [3]).

2.2 Quasi-static stiffness

2.2.1 The linear quasi-static stiffness is used to model the variation of tension around the pre-tension of the line. It is also used to derive the quasi-static characteristic in long-term conditions (see [2.3.2]).

2.2.2 The quasi-static stiffness is obtained by the quasi-static stiffness test described in App 1, [4].

In this test, after a proper bedding-in, the rope is cycled between two tension levels, over several cycles, each having a duration of 1 h (twice 30 minutes). This cycling is performed to get rid of the initial condition of rope on the test bench, not representative of actual condition.

2.2.3 The value of Krs obtained from test is related to the duration of half cycles (1/2 h) (see App 1, [4.5.1]). For the design, this value of Krs obtained from test is to be extrapolated for a duration that is representative of the rise time τ of the metocean events to be considered (several hours / days).

This extrapolation is achieved by the following procedure (see [1.8.3]), in which the duration τ is normally taken as 12 h:

a) The elongation X_τ at the end of each of the two last 1/2 cycle of duration τ, is derived from a fitting of the creep (or recovery) elongation over the tension's plateau as:

$X(t) = X_p + a_c \log[1 + (t - t_p) / t_a]$

where:

X_p	:	Elongation of the rope sample at time t_p
a_c	:	Creep "per decade" over the plateau
t_p	:	Time at a point along the load plateau (any point)
t_a	:	Time scale constant

with a_c, t_a, and X_p being obtained by a three-parameter fit of the elongation versus time over the loading plateau.

Note 1: This fit is independent of time unit and time origin, and the result does not depend on the selection of t_p.

b) The elongation X_τ is then obtained as follows:

$X_\tau = X_p + a_c \log(\tau / t_a)$

c) A linearised quasi-static stiffness Krs_τ is then given by:

$Krs_\tau = (T_2 - T_1) / (X_{2\tau} - X_{1\tau})$

where:

T_1, T_2	:	Tensions during the plateau of the two successive last 1/2 cycles (in % of the MBS), normally taken as 10% and 30% of the MBS
$X_{1\tau}$, $X_{2\tau}$	:	Calculated elongation at the end of these 1/2 cycles.

Note 2: Longer duration τ could be more appropriate for some metocean events (e.g. 7 days for the rising time of a loop current event).

2.3 Quasi-static characteristics (polyester)

2.3.1 General

The quasi-static characteristics provide the relation between the rope mean tension and the stabilised mean elongation, over the full range of tensions likely to occur in operation, ascending (in windward line) or descending (in leeward lines) from the tension in calm conditions.

Note 1: See [1.8.3] for background information.

2.3.2 Long-term conditions

a) For the long-term conditions, the elongation of rope $X_{LTu}(T)$ and $X_{LTd}(T)$ are given by the following formulae (see Fig 1):

- for $T \geq 10\%$:

  $X_{LTu}(T) = X_{pt0} + (T - T_0) / Krs_{12h}$

- for $T < 10\%$:

  $X_{LTd}(T) = X_{LTu}(10) - 10 / Krs_{12h} \cdot (u + u_a \cdot u^{ub})$

where:

$u = 1 - T / 10$

T : Rope mean tension

T_0 : Tension for rope length assessment (see [1.7])

X_{LTu}, X_{LTd}: Rope elongation with respect to the reference length L_{T0} (see [1.7])

X_{pt0} : Long-term permanent elongation (with respect to L_{T0}) function of T_0 (see Note 3 and [4.1.4])

Krs_{12h} : Quasi-static stiffness between 10 and 30%, for a duration τ of 12 h, as per [2.2]

u_a , u_b : Constants defined in [4.1.4].

b) For the pre-tension T_{pt} (i.e. assuming re-tensioning), the elongation X_{pt} for setting of the system is given by:

$X_{pt} = (T_{pt} - T_0) / Krs_{12h}$

Note 1: These formulae are given for a duration τ of 12 h. For longer durations, see [1.8.1].

Note 2: The upper branch X_{LTu} (ascending tensions) includes the additional permanent elongation for tensions above 42% (see Fig 1).

Note 3: For $T_0 = 20$, $X_{pt0} = X_{p20}$

When a different value of T_0 is used in Linear Density test, X_{pt0} may be estimated as follows:

$X_{pt0} = [X_{p20} + (20 - T_0).\ a_{20}] \cdot (1 + DX_{t0} / 100)$

where:

- $DX_{t0} = (20 - T_0).\ (1/ Krs_{12h} + a_{20})$
- X_{p20}, a_{20} : constants defined in [4.1.4]).

2.3.3 Early life conditions (newly installed system)

In the early life situations, the permanent elongation will progressively develop with successive storm events.

a) The difference $dX_p(T)$ between the permanent elongations in long term and early life conditions is taken as follows:

- For $T \leq 42\%$:

  $dX_p(T) = a_p \cdot (T - 20) - X_{pt0}$
- for $T > 42\%$:

  $dX_p(T) = b_p + c_p \cdot (T - 42) - X_{pt0}$

where:

a_p, b_p, c_p : Parameters function of T_0 (see Note 1 and [4.1.4])

T, X_{pt0} : See [2.3.2].

b) The permanent elongations in early life conditions $X_{nu}(T)$ and $X_{nd}(T)$ are then given by (see Fig 1):

- For $T \geq T_a$:

  $X_{nu}(T) = X_{LTu}(T) + dX_p(T)$
- For $T < T_a$:

  $X_{nd}(T) = X_{LTu}(T) + dX_p(T_a)$

where:

T_a : Latest highest achieved (sustained) mean tension in the line being considered before the condition to be analysed (generally the pre-tension T_{pt})

X_{LTu} : See [2.3.2].

c) For the pre-tension T_{pt} (i.e. assuming re-tensioning), the elongation X_{pt} for setting of the system is given by:

$X_{pt} = X_{nd}(T_{pt})$

Note 1: For $T_0=20$:

- $a_p= a_{20}$
- $b_p= b_{20}$
- $c_p= c_{20}$

When a different value of T_0 is used in Linear Density test, the parameters a_p, b_p and c_p may be estimated as:

$a_p = a_{20}\ (1 + DX_{t0} / 100)$

$b_p = b_{20}\ (1 + DX_{t0} / 100)$

$c_p = c_{20}\ (1 + DX_{t0} / 100)$

where:

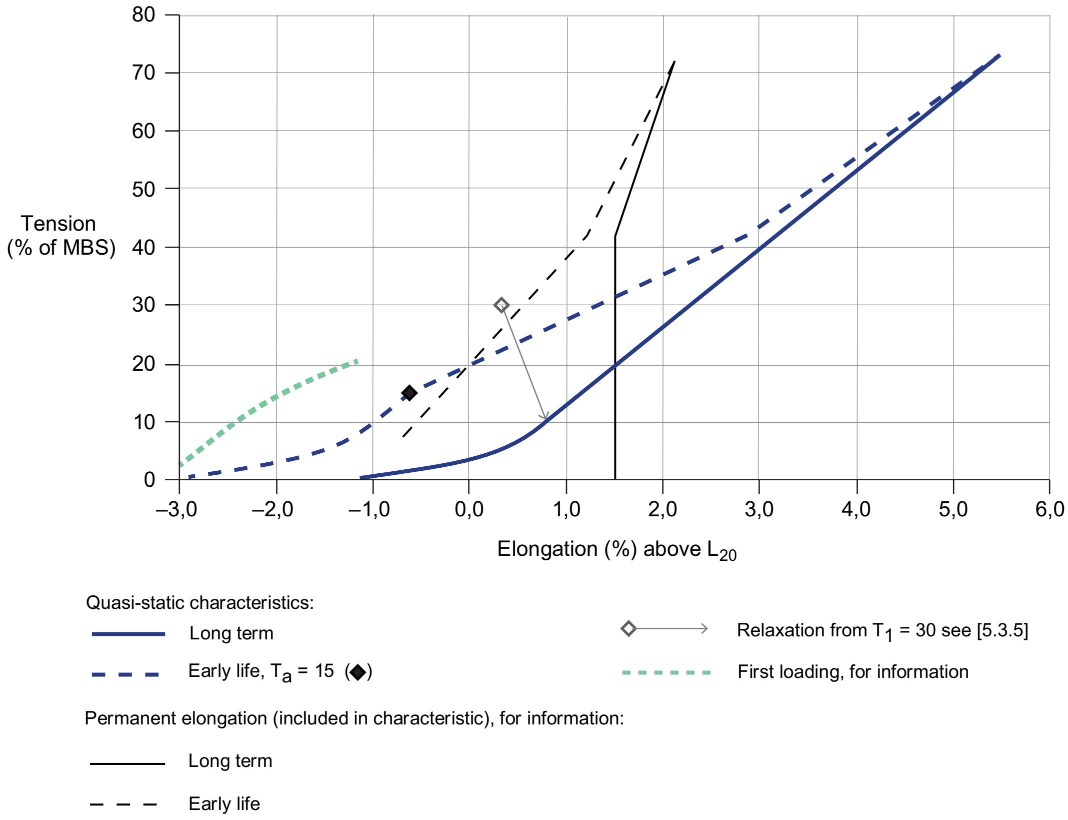
a_{20}, b_{20}, c_{20}: Constants defined in [4.1.4].

DX_{t0} : As per Note 3 of [2.3.2].

2.3.4 Long-term conditions - Systems without re-tensioning

For a particular system without re-tensioning, the procedure in [5.3.5] may be used to get stabilised (long-term) pre-tension in calm conditions (see also Fig 1).

Figure 1 : Illustration of polyester quasi-static characteristic (for T_0 = 20)



3 Dynamic response

3.1 Dynamic stiffness

3.1.1 A non-dimensional linear dynamic stiffness (see [1.5]) Krd, solely dependent on and increasing linearly with the mean tension in the rope (see [1.8.3]), is used to model the response to dynamic loadings (both the “wave frequency” and the “low frequency” loadings).

Krd is taken as follows:

Krd = a + b ML

where:

a, b : Constants depending on the material (see Article [4])

ML : Mean tension, in % of the MBS.

Note 1: For polyester and other high modulus materials, other parameters influencing the dynamic stiffness (load range, frequency) observed in early work are not deemed relevant: they were shown to have thermal origins, induced by hysteretic heating in testing conditions. They would be anyway difficult to account for in the analysis process.

Note 2: For rope qualification, measurements at three levels of mean tension and one tension range are deemed sufficient to confirm the applicability of data in [4]. However more data points are needed to derive with confidence (by linear regression) the Krd relation for a specific rope model (typically 100 cycles with a 10% load range, for 5 levels of mean tensions, from 10% to 50%, then down from 40% to 10%).

Note 3: During cycling on a test bench at a constant mean tension, the stiffness rapidly increases at the beginning of the run, then tends to stabilise. The measurements of the dynamic stiffness with a sufficient but limited number of cycles (100 to 300) after a standard bedding-in sequence, as specified in App 1, [4], will provide reliable data that may be deemed representative of the long-term conditions (see [1.7]), i.e. at the time when the design conditions happen, and also applicable to other conditions, given their limited dependence on load history.

4 Numerical data for polyester and high modulus materials

4.1 Polyester

4.1.1 General

The following data are applicable for polyester ropes that are “normally stiff ropes”, i.e. ropes with a “Krebi” between 18 and 23 (in the lower half of the range specified in Sec 6, [2.4]). These data should be used in the design of a particular stationkeeping system, unless more accurate data are available for the specific rope to be installed (see Note 2).

Note 1: See [1.8.3] for data references.

Note 2: For a specific rope model:

- Krd relation (following the equation in [3.1]) should be obtained from suitable tests, see Note 2 in [3.1]
- The quasi-static characteristic is given by scaling to the value of Krs12h derived from the quasi-static stiffness test.

4.1.2 Upper bound (rope with higher stiffness)

a) Quasi-static stiffness:

$Krs_{12h} = 13,3$

Note 1: Corresponding to a measured Krs of 16

b) Dynamic stiffness:

Krd = 18,5 + 0,33 ML

where:

ML : Mean tension, in% of the MBS

4.1.3 Lower bound (rope with lower stiffness)

Lower bound, whenever needed, is given by:

a) Quasi-static stiffness:

$Krs_{12h} = 10$

Note 1: Corresponding to a measured Krs of 12

b) Dynamic stiffness:

Krd = 15 + 0,25 ML

4.1.4 Quasi-static characteristics - numerical data

The values of constants in the equations of [2.3] are given in Tab 1.

Table 1 : Polyester Quasi-Static characteristic - numerical data

Term	Constant	Value	Unit **(1)**
Krs		see [4.1.2] and [4.1.3]	
X_{LTd}	u_a	1,8	–
	u_b	3,6	–
X_{LTu}	Xp_{20}	1,5	%e
dX_p	a_{20}	0,055	%e / %
	b_{20}	1,20	%e
	c_{20}	0,01	%e / %
(1) Tensions in % (see [1.7.4]), Elongations noted %e			

4.2 High modulus materials

4.2.1 The data presented in Tab 2 may be considered for ropes made of high modulus materials. They are given as guidance for preliminary stages only, and are not to be used in the design without proper validation.

Table 2 : High modulus materials - numerical data

Material	Quasi-static stiffness	Dynamic stiffness
HMPE	Krs = 55	Krd = 60 + 0,53 ML
Aramid	Krs = 45	Krd = 45 + 0,6 ML
Polyarylate	Krs = 30	Krd = 30 + 0,6 ML

5 Polyamide

5.1 General

5.1.1 Ropes made of polyamide are currently considered for Marine Renewable Energies (MRE) applications, given their higher elasticity than polyester ropes.

The load-elongation relations for polyamide may be formulated in the same way as for other materials (see [1]), however, besides the higher elasticity, they appear more complex and more non-linear, as outlined in this Article.

5.1.2 As the strength and stiffness of polyamide ropes are both affected by water, tensions are expressed in % of the wet MBS (see Note 2 in [1.3.1] and App 1, [2.2.2]).

5.2 Line length

5.2.1 For polyamide, the rope length at tension T_0 in wet conditions may be taken equal to LT_0 (see [1.7]).

5.3 Quasi-static characteristics

5.3.1 The quasi-static characteristics provide, as for polyester, the relation between rope mean tension and the stabilised mean elongation, over the range of tensions likely to occur in operation. The model given in [5.3.2] to [5.3.6] is based on tests similar to those indicated in [1.8.3] for polyester.

5.3.2 The quasi-static characteristics is written as:

$X(T) = X_e + X_{ed} + X_p$

where:

X : Rope elongation with respect to the reference length LT_0 (see [5.2.1])

T : Rope mean tension

X_e : Elastic elongation (stabilised)

X_{ed} : Additional elastic elongation term (for low tensions)

X_p : Permanent (non-recoverable) elongation.

The elastic elongations terms X_e and X_{ed} are functions of mean tension T, and written as:

- $X_e = a_e \cdot \mathrm{Ln}(1 + T / f_e) + c_e$
  i.e. the tension vs elongation relation is a shifted exponential function
- $X_{ed} = - a_d \cdot \exp(- b_d \cdot T)$
  for low tensions

where a_e, f_e, c_e, a_d and b_d are constants defined in [5.3.6].

The permanent elongation X_p is a function of the condition to be analysed (see [5.3.3] to [5.3.5]).

5.3.3 Long-term conditions

a) The permanent elongation in long-term conditions X_{plt} is taken as follows:

- for $T \leq f_{lp}$:
  $X_{plt} = a_{lp}$
- for $T > f_{lp}$:
  $X_{plt} = a_{lp} + b_{lp} \cdot (-1 + T / f_{lp})^2$

where:

f_{lp}, a_{lp} and b_{lp}:Constants defined in [5.3.6]

T : See [5.3.2]

Note 1: Some additional long-term creep elongation can be anticipated, but a quantification of it is currently not available.

b) The rope elongation in long-term conditions $X_{LTu}(T)$ and $X_{LTd}(T)$ can then be written as (see also Fig 2):

- for $T \geq T_{pt}$:
  $X_{LTu}(T) = X_e(T) + X_{ed}(T) + X_{plt}(T)$
- for $T \leq T_{pt}$:
  $X_{LTd}(T) = X_e(T) + X_{ed}(T) + X_{plt}(T_{pt})$

where:

T_{pt} : Rope design pre-tension (assuming re-tensioning)

X_e, X_{ed} : See [5.3.2]

c) For the setting of the system, the elongation at pre-tension T_{pt} is given by:

$X_{pt} = X_{LTu}(T_{pt})$

5.3.4 Early life conditions

a) The permanent elongation in early life conditions X_{pe} is given by:

- for T ≤ 22,5%:
  $X_{pe} = c_{ep} \cdot (T - 15)$
- for T > 22,5%:
  $X_{pe} = a_{ep} + b_{ep} \cdot (-1 + T / f_{ep})^2$

where:

T : See [5.3.2]

a_{ep}, b_{ep}, c_{ep}, d_{ep} and f_{ep} :Constants defined in [5.3.6].

b) The rope elongation in early-life conditions $X_{nu}(T)$ and $X_{nd}(T)$ is then written as (see also Fig 2):

- for $T \geq T_a$:

  $X_{nu}(T) = X_e(T) + X_{ed}(T) + X_{pe}(T)$

- for $T \leq T_a$:

  $X_{nd}(T) = X_e(T) + X_{ed}(T) + X_{pe}(T_a)$

where:

T_a : Latest highest achieved (sustained) mean tension in the line being considered before the condition to be analysed (generally the pre-tension T_{pt}).

X_e, X_{ed} : See [5.3.2]

c) For the pre-tension T_{pt} (i.e. assuming re-tensioning), the elongation X_{pt} for setting of the system is thus given by:

$X_{pt} = X_{nu}(T_{pt})$

5.3.5 Long-term conditions - Systems without re-tensioning (tentative)

For a system without re-tensioning, the following procedure is proposed, to get stabilised (long-term) pre-tension in calm conditions (see also Fig 2):

a) In the initial condition of the system, the rope will be at a Tension T_1, with an elongation X_1.The tensions T_1 and the resulting elongation X_1 will both depend on the installation procedure and should be documented by an "initial elongation test" on a new subrope (or rope) sample: see Sec 6, [3.2.3].

The setting of the system in analysis will be at T_1 and X_1, and the quasi-static characteristic will then be given by:

$X_{T1}(T) = X_{LT}(T) - X_{LT}(T_1) + X_1$

where X_{LT} is defined in [5.3.3].

b) With successive storms, the length of the rope will increase, resulting in a progressive drop of line pre-tension, until a point of equilibrium on the long-term characteristic is reached (see "relaxation" on Fig 2):

This can be obtained by:

- modelling lines with tension T_1, elongation X_1 and characteristic as in item a), then
- adding a "gap element" with length:

  $D_X = X_{pt0} - X_1$

  where X_{pt0} is defined in [2.3.2], to get the relaxation of the rope (and possibly of the lines)
- then getting the tension T_r and elongation X_r, as a point on the characteristic for long-term conditions.

5.3.6 Numerical data

The values of constants in the equations of [5.3.3] to [5.3.5] are given in Tab 3.

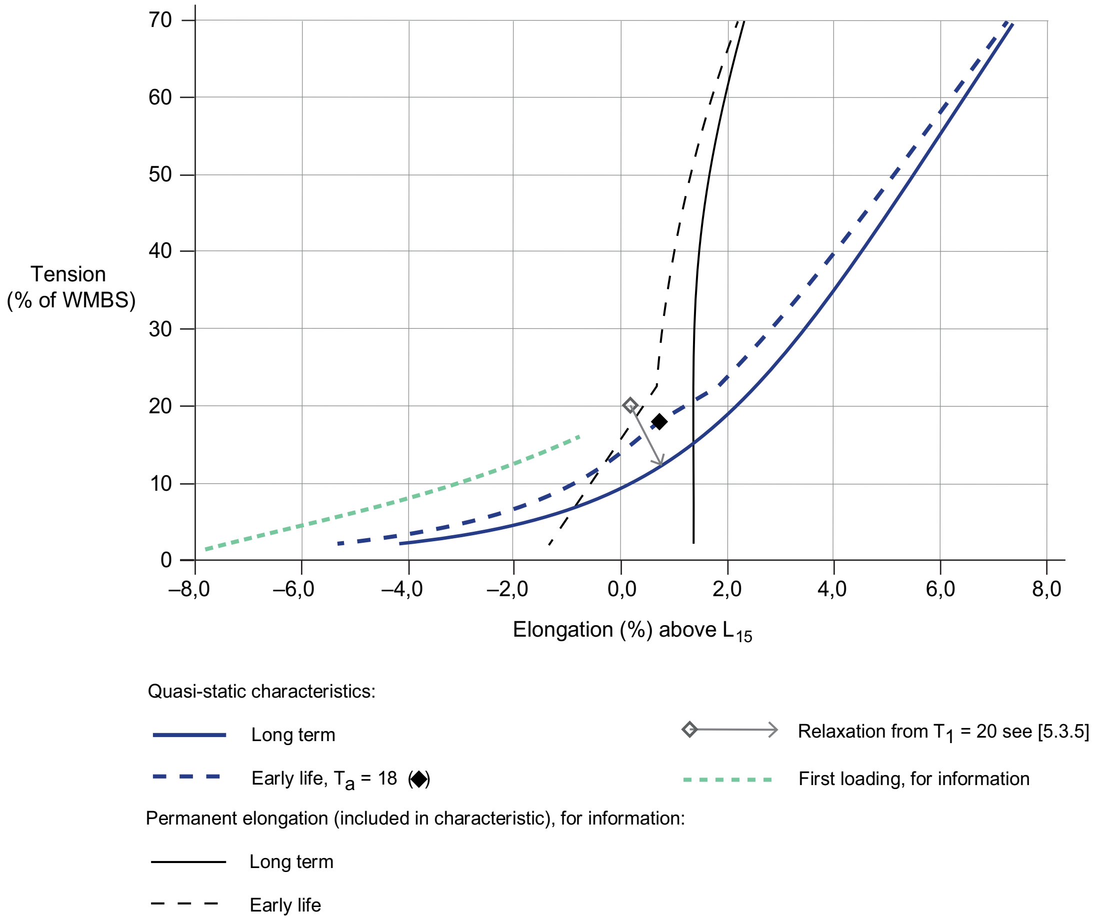
They are given as guidance for preliminary stages only, and are not to be used in design without proper validation.

Table 3 : Polyamide Quasi-Static characteristic - numerical data

Term	Constant	Value	Unit **(1)**
X_e	a_e	4,3	%e
	c_e	–4,15	%e
	f_e	9,25	%W
X_{ed}	a_d	5,0	%e
	b_d	0,40	$\%W^{-1}$
X_{plt}	a_p	1,44	%e
	b_p	0,28	%e
	f_p	24,4	%W
X_{pe}	a_{ep}	0,66	%e
	b_{ep}	0,03	%e
	c_{ep}	0,01	%e / %W
	f_{ep}	8,7	%W

(1) Tensions are given in % of the rope wet MBS (noted %W)
Elongations are noted %e

Figure 2 : Polyamide Quasi-Static characteristic (T_0 =15)



5.4 Dynamic response

5.4.1 Dynamic stiffness

The dynamic stiffness Krd of fully wetted polyamide ropes may be taken as follows:

Krd = b ML

where:

b = 0,43

ML : Mean tension, in % of the wet MBS

This indicative value can be used to model the response to dynamic loadings of moderate amplitudes but will not provide adequate estimates of extreme (maximum and minimum) tensions.

Note 1: The linearised dynamic stiffness is obtained from tests as defined in Sec 6, [3.2] and App 1, [4], at several mean tensions and a tension range of 10% of rope MBS.

However, it is also dependant on (and decreasing with) tension range. Besides, the response at the tension ranges of interest (e.g. for extremes) is not linear, with principally a curvature, and is dependent on time history. As a result of curvature, the tension maxima obtained using dynamic stiffness will be underestimated, and the occurrence of slack condition will be overestimated.

No practical model is currently available. An empirical (time domain) model is proposed in [1.8.5].

5.4.2 Envelope

When the line response can be considered as imposed displacements (i.e. floater motions not depending on the stiffness of lines), the tensions F at successive increasing maxima and decreasing minima within a given sea-state can be estimated from corresponding elongations, by the following envelope relations (see Fig 3):

- Upward envelope (X > 0):
  - General:

    $$F_f = [(X + u_a) \cdot u_b]^{u_c}$$

  - For small X (below about 1,1):

    $F_f = u_d X$

- Downward envelope (X < 0):

  $F_f = d_a \cdot \mathrm{arsinh}(d_b \cdot | X |)$

where:

X : Elongation expressed with respect to the (quasi-static) length of the rope L_{mean} under the tension F_{mean}

u_a, u_b, u_c, u_d, d_a, d_b, d_c:Constants defined in [5.4.3].

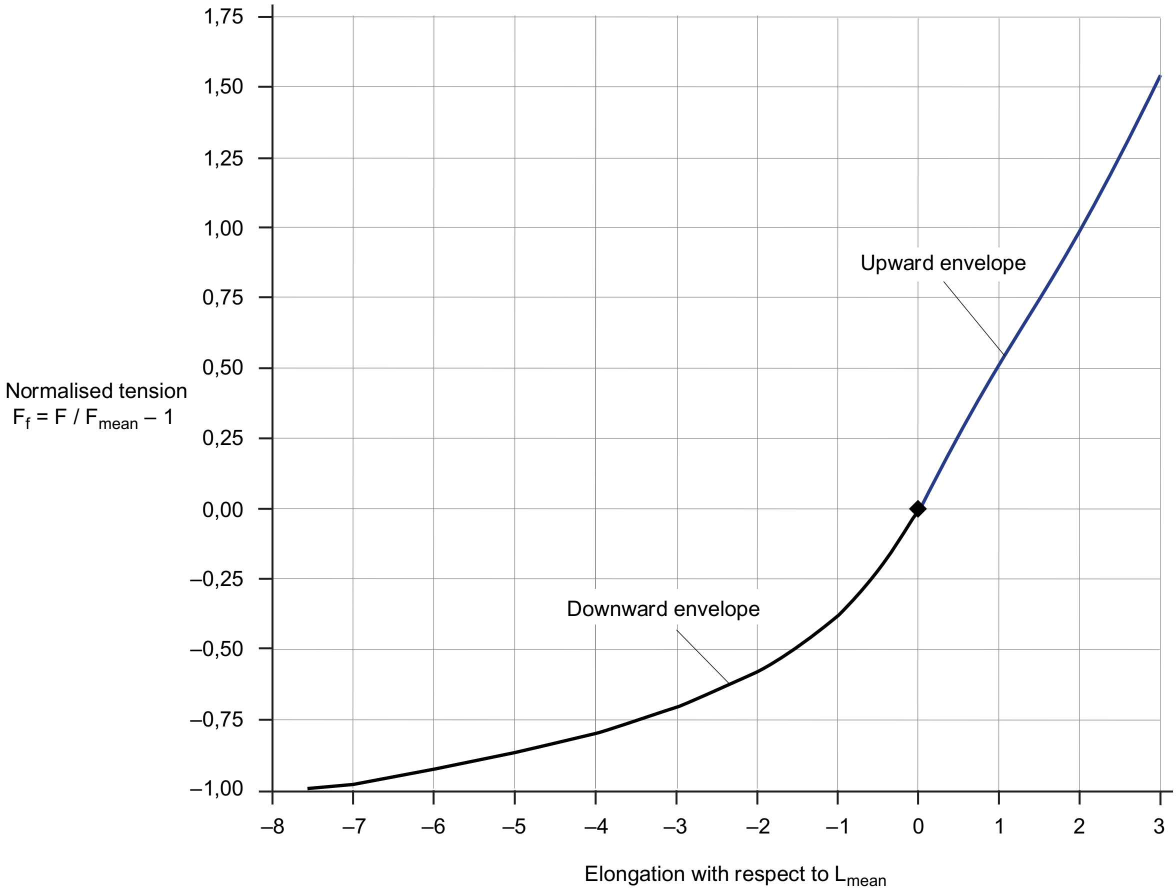
F_f : Rope tension F normalised by the mean tension F_{mean} during the sea-state analysed, as:

$F_f = F / F_{mean} - 1$

thus:

$F = F_{mean} \cdot (1 + F_f)$

Figure 3 : Envelope of dynamic tensions for polyamide



5.4.3 Numerical data

The data given in Tab 4 may be considered in equations presented in [5.4.2]. They are given as guidance for preliminary stages only, and are not to be used in design without proper validation.

Table 4 : Polyamide Quasi-Static characteristic - numerical data

Term	Constant	Value	Unit **(1)**
Upward envelope	u_a	1,1	%e
	u_b	0,32	$\%e^{-1}$
	u_c	1,6	–
	u_d	0,52	$\%e^{-1}$
Downward envelope	d_a	–0,32	–
	d_b	1,5	$\%e^{-1}$
(1) Elongations in % of L_{mean} (noted %e)			

Appendix 3 Templates for Data Sheet

1 General

1.1

1.1.1 A template for Data sheet - Summary of rope Design is provided in Tab 1.

A template for Data sheet - Rope design - Construction details is provided in Tab 2.

A template for Rope supply data sheet is provided in Tab 3.

Table 1 : Summary of rope design

General information	Manufacturer	
	Product name / Rope model	
	Type of service	
	Outside diameter (in mm):	
	Minimum Breaking Strength MBS (in kN):	
Fibre	Material	
	Supplier	
	Designation	

Rope core	Construction	
	Torque behaviour	
Cover	Material	
	Construction	
	Particle ingress protection	
Termination	Type	
	Termination fittings	
	Typical Assembly DWG	

Other information	

Table 2 : Rope design - Construction details

General information	Manufacturer		
	Product name / Rope model		
	Size		
	Type of service		
Fibre	Rope core fibre	Material	
		Fibre supplier & Designation	
		Size (dTex)	
	Cover fibre	Material	
		Fibre supplier & Designation	
		Size (dTex)	

Rope construction						
Item **(1)**			Number of components	Construction **(2)**	Size (dTex or mm or kg/m)	Pitch (mm) or torsion (t/m)
Core	Yarn					
	Intermediate yarn					
	Strand					
	Sub rope					
	Rope core					
	Linear density (kg/m)					
Coating	Designation					
	Mass (kg/m)					
Cover	Yarn					
	Intermediate yarn					
	Strand					
	Particle ingress protection weight (kg/m)					
	Linear density (in kg/m)					
	Thickness (mm)					
Rope	Linear density (in kg/m)					
	Diameter (mm)					
Terminations	Type					
	Cover material					
	Coating					
	Assembly DRWG					
	Dimensions	Inside radius (mm)				
		Eye length (mm)				
		Length of splice (mm)				
	Thimble	Material				
		Supplier				
		Test load				
		DWG				

Other informations

(1) List to be adjusted to proposed construction
(2) Parallel, laid or braided

Table 3 : Rope supply data sheet

PROJECT		
Manufacturer		
Product name / Rope model		
Type of service		
Dimensions	Outside diameter (in mm):	
	Minimum Breaking Strength MBS (in kN):	
Reference rope approval		
	Manufacturer's signature	

Rope particulars	Rope core material	
	Torque behaviour	
	Particle ingress protection	
	Termination type	
	Termination fittings	
	Typical assembly drawing	
Remarks		

Item designation	Number in supply	Length at.............load	Assembly drawing

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