



STANDARD FOR CERTIFICATION

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Approval Programme No. 322

YARNS FOR OFFSHORE MOORING FIBRE ROPES

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DET NORSKE VERITAS

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1. General

1.1 Scope

This programme gives the procedure to be followed to obtain the Society's approval for the manufacture of: Load bearing yarns for offshore mooring fibre ropes, in accordance with DNV Offshore Standard, DNV-OS-E303.

This programme covers synthetic fibre materials for offshore moorings, such as polyester, polyamide, aramid, LCF/LCAF and HMPE.

In the context of this programme, 'yarn' is defined as finished yarn as delivered by the yarn-manufacturing facility, including first conversion for further processing by the rope manufacturer.

1.2 Range of approval

Approval is required for each type designation, i.e. product name (grade) with list of weight (variants), amount of twist and type and amount of coating.

1.3 Validity and Renewal

The approval will be valid for four years. To maintain the approved status, the manufacturer must be re-inspected every four years. Application for renewal should be made not later than three months before the expiry date of the certificate.

Any significant alteration to the approved condition during the period of validity, as described in the approval documentation (chapter 3) shall be reported to the Society. A re-inspection and/or re-testing may be required when deemed necessary by the Society.

1.4 Extension or Change of Approval

An existing approval of manufacturer certificate may be extended with respect to the "range of approval".

Approval Documentation:

— For extensions or changes to the approval conditions, the approval documentation specified in chapter 3 and already submitted during the initial approval process, need not to be re-submitted. However, the documentation related to changes to the manufacturing process shall be submitted.

Approval Testing:

— For extensions of an existing approval to include new type designation; full approval testing according to chapter 4 is required.

2. Approval Procedure

2.1 Application

Application for approval should be sent to the local DNV office together with the following information:

- a) Name and site address of the manufacturer.
- b) A list of products for which approval is requested.
- c) Manufacturing description, including testing and inspection facilities and equipment.
- d) Approval-testing specification.

The information will be forwarded to Responsible Approval Centre for review and request of additional documentation as required.

2.2 Works Inspection and Approval Testing

The surveyor may request additional documentation for his preparation for the works inspection to be performed.

After receipt and review of the requested information the DNV surveyor will carry out a works inspection to verify that the necessary manufacturing, testing, and inspection facilities are available and supervised by qualified personnel.

Approval testing shall be witnessed by DNV.

2.3 Submission of Approval Application Report

On completion of approval testing, the manufacturer shall prepare and submit a complete approval application report.

The approval report shall be organized in the same order and with the same indexing as described in this programme, containing all the information requested in chapters 2.1, 3 and 4.

The approval report shall be signed and dated by the manufacturer's representative, and sent to the local DNV office.

2.4 Evaluation of the Approval Report

When received at the local DNV office, the approval report shall be endorsed, that is; the surveyor will confirm the completeness of the report and the correctness of the test results and forward the report to Responsible Approval Centre for evaluation, together with the applicable checklists.

2.5 Issue of Approval of Manufacturer Certificate

Manufacturers whose works have been inspected and whose approval documentation has been reviewed with satisfactory result will be granted an "Approval of Manufacturer Certificate". A list of approved manufacturers is provided on DNV Exchange on the internet (<http://exchange.dnv.com/tari>).

3. Approval Documentation

This section lists the general information to be provided. The language of the submitted documentation shall be English.

3.1 General Manufacturer Information

- a) An outline of the organisation structure including quality control responsibilities.
- b) Manufacturing description, including the finishing/coating process and handling of non-conformities.
- c) A list of written procedures for testing and inspection. The procedures shall be available for review.
- d) A list of equipment used for drawing processes, heat treatment and finish.
- e) Programme for calibration of equipment.
- f) Description of the qualifications of personnel engaged in production, testing and inspection.
- g) Procedure for product identification and traceability (including test samples).
- h) Name of sub suppliers with site address.
- i) Measures to maintain raw material consistency.
- j) Procedure for handling and packing of the product from yarn manufacturer to rope manufacturer.

3.2 Product Information

For all designations for approval, a list or table specifying the following shall be given:

- a) Fibre type and chemical composition.
- b) Product name (grade) and variants.
- c) Range of dimensions.
- d) Specification for mechanical properties with tolerances (ref. Table 4-1).
- e) Type, designation and amount of coating.
- f) Yarn specification and amount of twist at delivery.
- g) Linear density (dtex) and weight tolerances.
- h) Specified maximum moisture content.
- i) Areas of application and limitations of the product.

3.3 Manufacturers' own Certificate Form

Where the manufacturer's own certificate form is intended to be used and validated by DNV, a filled-in example shall be submitted for review.

3.4 Manufacturing description

The manufacturing description shall completely describe each step in the production process of the yarn material. It shall also provide an overview of the production in general.

For each step in the production process, aspects of particular importance shall be identified and it shall be explained how these aspects are taken care of by the techniques of manufacturing and quality control. The risk and implications of deviations shall be elaborated.

The manufacturer's written procedures for testing and inspection shall reflect the described important aspects.

The manufacturer shall describe what measures are taken to ensure uniformity of feed stock.

3.5 Test Report

Test reports describing the tests carried out shall be issued to DNV.

4. Approval Testing

This chapter is applicable for yarns with stress-rupture behaviour under constant tension. Creep failure behaviour will be addressed on a case-by-case basis.

4.1 General requirements

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

In case the test results for the approval testing fail to meet the requirements, retesting of the same yarn is generally not permitted. However, the manufacturer shall evaluate the cause for the failure and implement corrective measures. An evaluation report shall be submitted to DNV together with the approval report. Approval testing on new yarns after corrective actions will generally be required.

Approval tests shall be witnessed by DNV's surveyor. If the testing facilities are not available at the works, the tests shall be carried out at an independent, recognised laboratory.

4.2 Test material

For each designation for which approval is requested, approval testing shall be carried out on yarns of the maximum linear density.

4.3 Testing of yarn

Testing for approval shall be performed on test samples taken from at least two batches of production. The test method, number and selection of parallels and acceptance criteria for each parameter are given in Table 4-1.

<i>Test types</i>	<i>Reference standards ¹⁾</i>	<i>Number of tests</i>	<i>To be stated on certificate</i>
Chemical composition	Specified by the manufacturer	Specified by the manufacturer	N/A
Force vs. stretch	ASTM D885M	10 parallels from at least 2 batches	Characteristic value
Time-to-rupture ²⁾	Specified by the manufacturer	24 samples from at least 2 batches	Characteristic value
Design range testing	Specified by the manufacturer	24 samples from at least 2 batches	Permissible design loading range
Yarn on yarn abrasion	CI 1503	Specified by the manufacturer	Specified by the manufacturer
Glass-rubber transition	Specified by the manufacturer	Specified by the manufacturer	Specified by the manufacturer
1) If sampling is not given by the reference standard, sampling may be based on ASTM D2258M. Other reference standards may be accepted in agreement with DNV. 2) Either time-to-rupture or creep-failure testing shall be carried out, depending on the material. Scope of testing for creep failure will be determined on a case-by-case basis.			

Testing in connection with retention of the approval shall be performed on test samples taken from production for yarn delivery for mooring ropes. Samples shall be taken on each delivery, minimum four times during approval period; otherwise additional tests from different batches are needed to make a total of at least four independent test series. At least one of the samples shall be from the last years production.

For retention survey testing where the fibre has been changed, testing shall be performed as for initial approval.

The test method, minimum number and selection of parallels and acceptance criteria for each parameter are given in Table 4-2.

<i>Test type</i>	<i>Reference standard ¹⁾</i>	<i>Number of tests</i>	<i>To be stated in certificate</i>
Chemical composition	Specified by the manufacturer	Specified by the manufacturer	N/A
Force vs. stretch	ASTM D885M	10 parallels from at least 2 batches	Characteristic value
Time-to-rupture	Specified by the manufacturer	6 parallels from at least 2 batches	Characteristic value
Design range testing ²⁾	Specified by the manufacturer	6 parallels from at least 2 batches	Permissible design loading range
Yarn on yarn abrasion	CI 1503	Specified by the manufacturer	Specified by the manufacturer
Glass-rubber transition	Specified by the manufacturer	Specified by the manufacturer	Specified by the manufacturer
1) If sampling is not given by the reference standard, sampling may be based on ASTM D2258M. Other reference standards may be accepted in agreement with DNV. 2) Either time-to-rupture or creep-failure testing shall be carried out, depending on the material. Scope of testing for creep failure will be determined on a case-by-case basis.			

4.4 Force vs. Stretch testing

For approval testing, force vs. stretch properties of the yarn shall be measured when loaded at a constant rate until break. The force vs. strain curve shall be recorded.

Yarn strain shall be measured with extensometer (not to be taken from cross-head displacement).

For approval testing, the standard deviation shall be taken as representative of continuous production. The standard deviation shall account for data from past production records, if available. The standard deviation from approval testing is normally lower than the actual standard deviation from continuous yarn production.

For testing in relation to retention of the approval, the mean and standard deviation shall also account for the tests performed on samples from production.

Strength and stiffness shall be represented in terms of characteristic values established based on measurements on test specimens. For estimation of characteristic values from test data, the following statistical properties are needed:

— Sample mean

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

— Sample standard deviation

$$s = \sqrt{\frac{1}{n-1} \sum_{i=1}^n (x_i - \bar{x})^2}$$

— Sample coefficient of variation

$$COV = \frac{s}{\bar{x}}$$

Here, $x_i, i=1, \dots, n$, are the n observations of the material property to be estimated, obtained from tests.

The characteristic value of strength is defined as a low 2.5-% quantile in the distribution of the arbitrary strength. When characteristic values of strength are estimated from data, the estimate shall be given with confidence. Characteristic values of strength for use in design shall be estimated with 95% confidence. Characteristic values can be estimated with confidence in accordance with Table 4-3.

<i>2.5-% quantile estimated with confidence</i>	
$x_c = \bar{x} - c(n) \cdot s$	
No. of measurements, n	$c(n)$
	<i>Confidence 95%</i>
3	9.0
4	6.0
5	4.9
6	4.3
7	4.0
8	3.7
9	3.5

Table 4-3 Characteristic value (Continued)	
<i>2.5-% quantile estimated with confidence</i>	
$x_c = \bar{x} - c(n) \cdot s$	
No. of measurements, <i>n</i>	<i>c(n)</i>
	<i>Confidence 95%</i>
10	3.4
12	3.2
15	3.0
20	2.8
25	2.7
30	2.6
40	2.5
50	2.4
∞	2.0

Characteristic values for modulus is defined as the mean value. The characteristic value can be estimated by the sample mean of stiffness data from tests.

Average and standard deviation shall be reported for modulus, force and strain at break.

Location of failure shall be reported; free length or grips.

4.5 Time-to-rupture testing / creep failure testing

Unless another test programme is shown to be appropriate, the time-to-rupture tests specified in Table 4-4 shall be performed.

The TTR testing is performed to provide a qualitative measure that sustained, high loads such as a loop current event with one line missing can be tolerated.

The test temperature should be 20°C or otherwise as stated in the approval-testing specification.

Table 4-4 Test requirements – Stress rupture		
<i>Load level (% average value from force vs. stretch testing)</i>	<i>Minimum number and selection of samples</i>	<i>Frequency of testing</i>
80	6 samples from at least 2 batches	Approval testing
83	6 samples from at least 2 batches	Approval and retention testing
87	6 samples from at least 2 batches	Approval testing
90	6 samples from at least 2 batches	Approval testing
For retention of the approval, the mean and standard deviation shall also account for the tests performed on samples from production.		

Characteristic values for the coefficients of the TTR curve shall be reported and will be stated on the yarn certificate.

The characteristic curve is defined as a low 2.5-% quantile estimated with 95% confidence. The expected (mean) curve is established by curve-fitting. The characteristic curve to be used in design is obtained by shifting the expected curve in the direction of shorter survival times to account for the uncertainty in the curve and achieve the above-specified formal definition. This can be achieved by shifting the expected curve by k_m standard deviations of $\log(t)$. The k_m -factor is given in Table 4-5.

Table 4-5 The factor k_m for calculation of characteristic TTR curve	
<i>Number of test specimens</i>	k_m
10	4.7
15	4.0
20	3.7
50	3.0
100	2.6
∞	2.0

For yarns that exhibit creep failure rather than stress rupture the approval testing programme should be established on a case-by-case basis.

4.6 Design range testing

For approval and retention survey, cycles to failure shall be tested to demonstrate the permissible design range. Unless another test programme is shown to be appropriate, the tests specified in Table 4-6 shall be performed.

<i>Mean tension (% avs)</i>	<i>Amplitude (% avs)</i>	<i>Minimum number and selection of samples</i>	<i>Loading frequency</i>	<i>Frequency of testing</i>
74	9	6 samples from at least 2 batches at each frequency	0.1 Hz and 0.01 Hz	Approval testing
61.5	21.5	6 samples from at least 2 batches at each frequency	0.1 Hz	Approval and retention testing
			0.01 Hz	Approval testing
At least 4 out of 6 samples for each loading frequency shall exhibit break away from the terminations.				

5. Suspension or Withdrawal of Certificates

An approval of manufacturer certificate may be suspended or withdrawn if the Society finds it justified.

Directions for suspension and withdrawal of an approval of manufacturer certificate are given by the Rules.

6. References

- 1) DNV-OS-E303, Offshore Mooring Fibre Ropes.
- 2) ASTM D885M, Standard Test Method for Tire Cords, Tire Cord Fabrics, and Industrial Filament Yarns Made from Manufactured Organic-Base Fibers.
- 3) CI 1503, Test Method for Yarn-on-Yarn Abrasion.
- 4) ASTM D2258M, Standard Practice for Sampling Yarn for Testing.