



STANDARD FOR CERTIFICATION

No. 2.9

Type Approval Programme No. 1-501.19

CARBON FIBRE REINFORCEMENTS

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FOREWORD

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A list of Standards for Certification is found in the latest edition of Pt.0 Ch.1 of the "Rules for Classification of Ships" and the "Rules for Classification of High Speed, Light Craft and Naval Surface Craft".

The list of Standards for Certification is also included in the current "Classification Services – Publications" issued by the Society, which is available on request. All publications may be ordered from the Society's Web site <http://webshop.dnv.com/global/>.

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CONTENTS

1. SCOPE OF SERVICES	4	3. DOCUMENTS TO BE SUBMITTED.....	5
2. PROCEDURE.....	4	3.1 Definitions	5
2.1 Application for Type Approval	4	4. REQUIREMENTS	5
2.2 Quotation	4	4.1 Basis for Type Approval	5
2.3 Assessment of Type Approval documentation	4	4.2 Scope of Type Approval	5
2.4 Initial Survey of product and production facilities including witnessing of Type Tests	4	4.3 Requirements to production and quality control arrangement.....	5
2.5 Assessment of survey report and Type Test results.....	4	4.4 Requirements to material and testing	6
2.6 Issuance of Type Approval Certificates	4	4.5 Requirements to laminates for Type Testing	7
2.7 Certificate Retention Survey after two (2) years	4	4.6 Requirement to packaging and marking of product	7
2.8 Application for renewal after four (4) years	4		

1. Scope of services

Det Norske Veritas (DNV) Type Approval is based on the ISO/IEC Guide 2 (1991) definition:

“Approval of conformity with specified requirements on the basis of systematic examination of one or more specimens of a product representative of the production.”

The requirements are specified in Rules and/or standards referred to in this Type Approval programme.

This Type Approval programme outlines the procedure and conditions for obtaining, maintaining and renewing a Type Approval. DNV Certification Notes No. 1.2 (2009) describes the Type Approval in general.

Type Approved products will be listed in DNV’s Register of Type Approved Products available on the DNV Internet site at <http://exchange.dnv.com/>.

2. Procedure

The Type Approval procedure normally consists of the following steps:

- application for Type Approval
- quotation
- assessment of Type Approval documentation
- Initial Survey of product and production facilities including witnessing of Type Tests
- assessment of survey report and Type Test results
- issuance of Type Approval Certificates
- Certificate Retention Survey after two (2) years
- application for renewal after four (4) years.

Explained in detail:

2.1 Application for Type Approval

The Type Approval should be applied for in writing to DNV’s local office. The application shall include Type Approval documentation as specified in section 3.

2.2 Quotation

A quotation will be given by DNV Approval Office, to be confirmed by the client.

2.3 Assessment of Type Approval documentation

The Type Approval documentation is assessed by DNV Approval office to verify that it is in conformity with the specified requirements.

2.4 Initial Survey of product and production facilities including witnessing of Type Tests

The objective of Initial Survey is to verify that the production, quality control arrangement, product design, material composition and the product marking is according to the Type Approval documentation.

The main elements of a DNV Initial Survey are:

- ensure that production and quality control arrangements are according to requirements as specified in section 4.3 and as stated in Type Approval documentation submitted by manufacturer
- witness Type Tests, as specified in sections 4.4.1 – 4.4.4 and 4.5 when applicable
- ensure traceability between manufacturer’s product marking and the type designation as stated in the application for Type Approval, ref. section 4.6.

The objective of Type Tests is to verify the ability of the product to meet specified requirements by subjecting the test sam-

ple to physical, chemical, environmental or operational stresses.

Type Tests as specified in section 4.4 are to be carried out and verified in one of the following ways:

- at a DNV laboratory
- at a recognised and independent laboratory accepted by DNV
- at the manufacturer’s premises in the presence of a DNV surveyor.

The Initial Survey report and Type Test results are to be submitted to DNV Approval Office for evaluation.

2.5 Assessment of survey report and Type Test results

The Initial Survey report and Type Test results are assessed in order to verify compliance with the requirements.

2.6 Issuance of Type Approval Certificates

When the assessment of Type Approval documentation, Type Testing and survey of production and quality control arrangement is successfully completed a Type Approval Certificate will be issued to the manufacturer of the product. The certificate is normally given a validity period of four (4) years, with a Certificate Retention Survey after two (2) years.

2.7 Certificate Retention Survey after two (2) years

The objective of the Certificate Retention Survey is to verify that the product design, material composition and the product marking are not altered since issuance of the Type Approval Certificate.

Certificate Retention Survey is to be carried out two (2) years after issuance of Type Approval Certificate.

The main elements of the Certificate Retention Survey are:

- ensure that Type Approval documentation is available.
- review design, materials, performance and production process (as specified in section 4.3) with respect to possible changes, in order to ensure compliance with Type Approval documentation and/or referenced material specifications.
- ensure traceability between manufacturer’s product marking and the DNV Type Approval Certificate as stated in section 4.6.
- witness tests/inspection on factory samples, selected at random from the production line (where practicable), or storage, if specified in section 4.4 and 4.5.

The Certificate Retention Survey report shall conclude that either:

- a) the Type Approval Certificate shall be retained,
or
- b) the Type Approval Certificate shall be modified/recalled due to the changes in the basis for approval.

The Certificate Retention Survey report shall be submitted to the manufacturer and to DNV Approval Office.

2.8 Application for renewal after four (4) years

Application for renewal should be submitted to DNV not later than three (3) months before expiry date of the Type Approval Certificate.

The application shall include updated Type Approval documentation as specified in section 3, item 1-5. Items 6-9 shall be submitted if changes have been implemented since last issuance of the Type Approval.

Upon receipt of the application, DNV will perform a Renewal Survey with objective to verify that the product design, material composition and the product marking are not altered since issuance of the Type Approval Certificate.

Renewal Survey is to be carried out not later than four (4) years after issuance of the Type Approval Certificate.

The main elements of a Renewal Survey are the same as specified for the Certificate Retention Survey in section 2.7.

If there, since last issuance of the Type Approval Certificate, has been any change in the relevant standards or in DNV Rules, new assessment of product and Type Tests may be required.

The Renewal Survey report will constitute part of the basis for renewal of the Type Approval Certificate.

3. Documents to be submitted

The following Type Approval documentation is to be submitted by the manufacturer at Initial Type Approval and updated, at renewal. The documentation shall be in triplicate, one copy will be returned to the manufacturer with the Type Approval Certificate and one to the local DNV station/surveyor. The documentation shall be in English, if not otherwise agreed. (Please number documentation according to below list to facilitate review):

- 1) Type designation, i.e. product name (grade) with list of weight (variants) to be included in and stated on the Type Approval Certificate.
- 2) Name and address of manufacturer, to be listed on Type Approval Certificate. Additionally, the following shall be specified, if applicable:
 - person in charge
 - phone number and fax numbers
 - e-mail and web address
- 3) Level of approval applied for (ref. section 4).
- 4) Product specification/data sheet for all variants, including:
 - precursor (PAN, pitch, cellulose, etc.)
 - processing of fibres, if relevant
 - fibre type (designation and sizing)
 - fabric/weave sizing (if used)
 - fabric/weave construction, if relevant
 - linear density, tex no.
 - weight per unit area, if relevant
 - specified max. moisture content
 - specified loss on ignition/size content
- 5) Areas of Application and Limitations of the product, including handling instructions, etc.
- 6) Description of production processes *)
- 7) Description of quality control arrangement *)
- 8) Description of packing of product *)
- 9) Information regarding marking of the product *)

*) To be verified at Initial Survey prior to issuance of Type Approval Certificate.

3.1 Definitions

<i>mean</i>	= arithmetic mean of Type Test results
<i>sdev</i>	= standard deviation of Type Test results
<i>msv</i>	= manufacturer's specified value

<i>Initial</i>	= Initial Type Approval Survey
<i>Retention</i>	= Certificate Retention Survey, carried out after two (2) years
<i>Renewal</i>	= Renewal Survey, carried out after four (4) years.

4. Requirements

4.1 Basis for Type Approval

This Type Approval Programme will be used for Type Approval of carbon fibre reinforcements for use in DNV classed vessels. Additional requirements may be found in:

- DNV Rules for Classification of High Speed, Light Craft and Naval Surface Craft
- DNV Standard for Certification No. 2.21, Craft
- DNV Standard for Certification No. 2.20, Lifeboats and Rescue Boats
- DNV Rules for Classification of Ships.

Type Approval of carbon fibre reinforcements shall involve documentation and evaluation of, at least:

- general properties
- tensile and compressive strength.

Evaluation of fatigue, impact and fire properties are not included, since they are a function of the laminate, and is to be evaluated during approval of classed objects.

Fatigue testing may, however, be required for types of fibres and production methods for which adequate experience as regards the behaviour under fatigue loading is not available (see also 4.4.3).

4.2 Scope of Type Approval

One DNV Type Approval Certificate will cover one grade, i.e. one fibre type (i.e. HS (Standard Modulus), IM, HM, UHM) and fabric/weave, if relevant (with defined fibre designation and sizing), with the possibility to include different weights as variants in the same certificate.

Reinforcements with different fibre type or fabric/weave, are considered as different grades and will be given different certificates.

The Type Approval is only valid for the type of fibre used for Type Testing and from one supplier. If the manufacturer wish to use other types of fibres or supplier than accepted for the initial approval, additional testing may have to be carried out.

The carbon fibres are to be produced as continuous fibres. They are to be tested in that product form which is to be used.

A type approval may be issued to:

- the manufacturer of the fibre - strands, UD's
- the manufacturer of fabrics, weaves, stitched products, tapes (UD's), etc.

One DNV Type Approval Certificate is limited to one manufacturer at one production site.

4.3 Requirements to production and quality control arrangement

The manufacturer shall have a quality system that meets ISO 9001 standards, or equivalent. If this quality standard is not fulfilled, the extent of testing and surveys will be specially considered.

The extent of the manufacturer's quality control during production shall at least be as listed either in Table 4-1 or Table 4-2,

as relevant, or at an equivalent level.

Control on	Test standard ¹⁾	Acceptance Criteria	Minimum level of verification	Frequency of control
Visual	Specified by the manuf./weaver	Specified by the manufacturer/weaver	Results documented in production log	Continuous during production
Linear density	ISO 1889-97	Mean ± 2 sdev within manuf. Nominal value $\pm 5\%$	Results documented in production log	Each batch
Moisture content	ISO 3344-97	Manufacturer's specified value (msv)	Results documented in production log	Each batch
Size content	ISO 10548-02	Manufacturer's specified value (msv)	Results documented in production log	Each batch
Strength and Modulus	Specified by the manuf./weaver	$\pm 5\%$ of nominal value	Documented by fibre producer, or by testing	For each batch of fibre
Elongation	Specified by the manuf./weaver	$\pm 5\%$ of nominal value		

1) Other standards may be agreed upon with the Society prior to testing.

Control on	Test standard ¹⁾	Acceptance Criteria	Minimum level of verification	Frequency of control
Visual	Specified by the manuf./weaver	Specified by weaver	Results documented in production log	Continuous during production
Linear density Weight per unit area	ISO 1889-97 ISO 3374-00	Mean ± 2 sdev within manuf. nominal value $\pm 5\%$ - strands/UD 10% - fabrics, weaves, etc.	Results documented in production log	Each batch
Moisture content	ISO 3344-97	Manufacturer's specified value (msv)	Results documented in production log	Each batch
Size content	ISO 10548-02	Manufacturer's specified value (msv)	Results documented in production log	Each batch
Strength and Modulus	ISO 527-1,4,5-97	$\pm 10\%$ of nominal value	Documented by fibre producer, or by testing	For each batch of fibre
Elongation	ISO 527-1,4,5-97	$\pm 10\%$ of nominal value		

1) Other standards may be agreed upon with the Society prior to testing.

4.4 Requirements to material and testing

criteria, minimum level of verification, and frequency of verification for each parameter are given in Table 4-3.

4.4.1 Physical properties

The test method, number and selection of parallels, acceptance

Property	Test standard ¹⁾	Number and selection of parallels	Acceptance criteria	Minimum level of verification	Frequency of verification
Moisture content	ISO 3344-97	10 parallels from at least 2 batches	Manufacturer's specified value (msv)	DNV Survey	Initial Retention Renewal Change of fibre
Size content	ISO 10548-94	10 parallels from at least 2 batches	Manufacturer's specified value (msv)	DNV Survey	
Linear density Weight per unit area	ISO 1889-97 ISO 3374-00	10 parallels from at least 2 batches	Mean ± 2 sdev within manuf. Nominal value $\pm 5\%$ - strands/UD 10% - fabrics, weaves, etc.	DNV Survey	

1) Other standards may be agreed upon with the Society prior to testing.

4.4.2 Tensile and Compressive Strength

Testing of tensile and compressive strength is *required* for carbon fibre reinforcements to be Type Approved. The objective of the testing is to verify the strength properties of the test laminates.

When Type Testing according to Table 4-3 and the below Table 4-4 has been carried out, and the results found to be satisfactory, the following will be added to the application text on the Type Approval Certificate:

“Tensile and compressive strength properties have been verified, and are listed on the certificate. The acceptability for specific applications will be evaluated case by case”.

The test results obtained will be taken for information and are

subject to evaluation in each separate case. Products with test results that do not fulfil the expectations to the product may be refused.

The results of the testing, i.e. the tensile and compressive strength, modulus, and elongation will be stated on page 2 of the certificate.

The laminates to be tested shall fulfil items i - v, in section 4.5. The tensile tests shall be performed in the main fibre directions of a fabric/weave.

The test method, number and selection of parallels, acceptance criteria, minimum level of verification, and frequency of verification for the tensile and compressive properties are described and summarised in below Table 4-4.

<i>Property</i>	<i>Test standard ¹⁾</i>	<i>Number and selection of parallels</i>	<i>Data format</i>	<i>Minimum level of verification</i>	<i>Frequency of verification</i>
Tensile	ISO 527-1,4,5-97	5 parallels from at least 2 batches	<i>Data from all individual tests</i>	DNV Survey	Initial
— strength					Change of fibre
— modulus					Change of supplier
— elongation					
Compressive	ISO 527-1,4,5-97 — with buckling re-vention	5 parallels from at least 2 batches	<i>Data from all individual tests</i>	DNV Survey	Initial
— strength					Change of fibre
— modulus					Change of supplier
— elongation					

1) Other standards may be agreed upon with the Society prior to testing.

4.4.3 Fatigue testing

Fatigue testing may be *required* for carbon reinforcements to be used in applications subject to fatigue loading, if behaviour under fatigue loading is not known (see section 4.1).

If fatigue testing has been carried out, and the results found to be satisfactory, the following will be added to the application text on the Type Approval Certificate: “*Fatigue properties have been verified, and are listed on the certificate*”.

The results of the fatigue testing will also be stated on page 2 of the certificate.

4.5 Requirements to laminates for Type Testing

Refer to description of testing above to determine which requirements are applicable.

- i) The laminate is to be made with an epoxy resins (or a marine grade polyester or vinylester, if relevant). The manufacturer may elect type of resin, but the Type Testing will only be valid for the type of resin used. The type of resin will be stated on the certificate
- ii) It is recommended that the laminate is cured at room temperature and atmospheric pressure. However another curing cycle may be chosen by the manufacturer, but the curing cycle will be stated on the certificate, and it is recommended that a curing cycle representative for common yard practise is selected.
- iii) The laminate shall have a fibre volume fraction as specified by the reinforcement manufacture. The fibre volume

fraction will be stated on the certificate. It is recommended that a fibre volume fraction obtainable in a yard is selected.

- iv) In general, for fabrics/weaves it is recommended that a typically stacking sequence as used in a yard is chosen for the laminate. Exceptions can be made if symmetric laminates are needed for testing; such cases shall be discussed with the Society.
- v) Test specimens shall be wide enough to cover at least four repeats of the structure of the weave/fabric.

4.6 Requirement to packaging and marking of product

The reinforcement shall be packed in order to protect the Carbon Fibre from the environment and shall be marked with at least following information:

- manufacturer's name
- production plant
- product name (grade)
- weight per unit length/area (variant)
- storage instructions.

The marking is to be carried out in such a way that it is visible, legible and indelible. The product name shall be the same as stated on the DNV Type Approval Certificate (ref. item 1 in section 3).