SECTION 5 WORKING PROCESS AND MECHANICAL TEST

1 General

1.1 Scope

1.1.1 As indicated in Ch 12, Sec 1, [1.2.2], the following three steps are necessary within the scope of yacht classification:

- Preliminary survey at yard
- Survey at work
- Samples' mechanical tests.

These three steps are described in the present section.

2 Preliminary survey at yard

2.1 Application

2.1.1 General

The preliminary survey is to be carried out for Shipyards not known to the Society.

This survey is intended to provide for the Society general information on the shipyard, so that production plant of composite hulls can be assessed.

The different information to document are described in the following requirements.

2.1.2 Shipyards

- Production sites
- Design office and production workforces
- Capacity (total and net surface areas)
- Production capacity (number of units per year, number of types, sizes)
- Total number of hull units already built
- Yard lay-out (showing zones assigned to different operations).

2.1.3 Raw materials used

- List of raw materials (gel-coats, resins, catalysts/ accelerators and/or hardeners, reinforcements, core materials, adhesives, etc.) with their reference and supplier's identification
- References of existing homologation and type approval certificates (Bureau Veritas or other), with copies
- Raw material data sheets, containing in particular the supplier's recommendations on storage and use, if available.

2.1.4 Storage site for raw materials

- Identification of storage site on yard lay-out plan (specifying all separated storage sites, the storage site equipped with ventilation and/or air conditioning system)
- Packaging of delivered consignments
- Storage conditions:
  - Summer maximum temperature and relative humidity
  - Winter minimum temperature and relative humidity
- Temperature monitoring (i.e. recording)
- Other environmental factor (hygrometry)
- Keeping and presence of logbook (e.g. consignment number, dates) for inventory control.

2.1.5 Raw material preparation units

- Resins and gel-coats:
  - Identification of preparation unit on lay-out plan
  - Manufacturer's specifications and recommendations
  - Resin blending method
  - Temperature monitoring
  - Preparation procedure
  - Method of supplying workstations
  - Accompanying data sheet.
- Reinforcement fabrics and core materials:
  - Identification of preparation area on lay-out plan
  - Preparation procedure
  - Method of supplying workstations
  - Accompanying data sheet.
- Gel-coating unit:
  - Locations with details of means of separation from other workshops
  - Equipment in gel-coating units (air conditioning, ventilation, dust extraction)
  - Hygrometry and temperature monitoring: number of hygrometers/thermometers, positioning, recording and height about ground level
  - Laying procedure
  - Moulds: type of mould, storage of moulds, preparation procedure (e.g. heating, cleaning, waxing)
  - Accompanying data sheet.
- Laminating unit:
  - Identification of laminating site on lay-out plan
  - Laminating method (e.g. hand or spray lay-up, prepregs, etc.)
  - Average time elapsing between application of layers
  - Hygrometry and temperature monitoring: minima and maxima of temperature and hygrometry
  - Location of hygrometer and thermometer in laminating unit.

- Assembly operations:
  - Types of assembly (e.g. glue-assembly, matting-in connection)
  - Physico-chemical preparations of parts for assembly
  - Areas of completion of such preparations (where such operations generate large amounts of dust, for instance, details are needed of precautions to limit teh effects on assembly work or other operations performed nearby, such as gel-coating or laminating).
- Traceability:
  - Data to ensure traceability of raw materials and equipment covered by the Society's Rules (from purchase order to installation or placing on vessel)
  - Data to ensure traceability of production means (describing different steps such as inspection or recording, during production)
  - Handing of non-conformities (from reception of materials or equipment to the end of construction)
  - Dealing with client complaints and returns to after-sales department.

3 Survey at work

3.1 General

3.1.1 Surveys at work by the Society during yacht hull construction are intended to ensure that method of production of composite hull complies with the Society and raw materials' suppliers requirements.

3.1.2 The surveys, carried out by Society's Surveyor, can only focus on the construction stage in progress during the survey and only permit a restricted visual examination on the completed construction stage coming before the survey.

It is necessary that the yard presents to the Surveyor a manufacturing plan ensuring traceability of hull construction progress.

A general lay-out for drafting this manufacturing plan, corresponding to the different important stages of construction, is proposed hereafter.

3.2 Content of manufacturing plan for Survey

3.2.1 Raw materials reference

The yard must draw up an exhaustive list of all raw materials used in manufacturing parts of composite hulls covered by the Society's Rules (shell plating, structural countermoulds, bulkheads, stiffeners and, in general, all elements contributing to hull strength).

These main materials comprise:

- gel-coats
- laminating or bonding resins
- reinforcements
- core materials for sandwich laminates
- glues and adhesives.

Yard documents contain the following information for each type of raw material:

- maker's name
- product supplier references
- Bureau Veritas product homologation references (number and date of validity of type approval certificates)
- homologation references from another classification Society (name and same information as in preceding point)
- supplier's special requirements, including at least:
  - minimum and maximum storage temperatures
  - minimum and maximum storage hygrometry
  - product packaging for delivery
  - packaging for storage
  - maximum shelf life of product
  - type of checks to be performed on incoming products and properties to be tested by yard before use.

3.2.2 Raw materials traceability

The raw materials' traceability must permit to identify the raw material batch reference used during each laminating stage of the hull as well as the preparation of raw materials before laminating, as for example:

- For gel-coats, resins and adhesives:
  - Amounts of various components necessary to prepare the resin systems in relation to the temperature in the laminating unit
  - Date and time of laminating.
- For reinforcement fabrics:
  - Precaution taken to prevent condensation caused by temperature difference
  - Identification of reinforcement fabrics and location in the hull
  - Date and time of laminating.
- For core materials:
  - Precaution taken to prevent condensation and to reduce the amount of gazing
  - Identification of core materials and adhesives used for laminating
  - Date and time of laminating.

3.2.3 Laminating

The different stages of the laminating process must be listed, indicating:

- Date and time of operation
- Temperature and hygrometry during operation
- Raw materials reference used
- Reference of laminating drawing used
- Directions of fabrics reinforcement
- Bubbles elimination operation
- Preparation of laminated zone intended for subsequent re-laminating or gluing.

3.2.4 Other laminating operations

The various laminating process as given hereafter are to be listed on the same basis than described in [3.2.3] for the following operations:

- Installation of internal structural components such as bulkheads, stiffeners
- chainplates when applicable
- connection between hull and deck.

3.3 Non Destructive Testing (NDT)

3.3.1 Application

Non destructive testing can be implemented by the yard.

The main testing processes used in yacht building are:

- Ultra-sonic testing
- Spectroscopy
- Differential Scanning Calorimetry
- Radiography.

4 Mechanical tests

4.1 General

4.1.1 Application

The present Article specifies the mechanical and physico-chemical tests to be performed on a test panel.

This test panel, which is representative of the construction of the hull, is used for mechanical tests, in order to check that the laminate produced by yard manufacturing methods possesses properties at least equivalent to the theoretical properties calculated on the basis of the requirements of the relevant Society's Rules, Ch 12, Sec 4.

Consequently, to be representative of yard production methods and of the hull under Classification, each test panel is to be:

- manufactured from the same raw materials as the hull for Classification
- manufactured by the same methods as the hulls for Classification and in the same environment
- of an similar composition as the hull scantling (arrangement of layers).

These tests are done in the laboratory of the Society, or a laboratory recognized by Bureau Veritas.

Note 1: It can be requested that where reinforcement fabrics are provided with direction different from 0°/90° in the hull, these fabrics can be replaced by 0°/90°direction to avoid test panel disruption.

4.2 Types of tests to be performed

4.2.1 General

Tests comprise destructive mechanical and physico-chemical tests.

The laminate panels are packaged, and test pieces prepared and dimensionally checked, in accordance with recognized standards.

4.2.2 Application

Tests are done on test pieces taken from the panel in two perpendicular directions. The number of test pieces in each direction depends on the reference standard (usually five in each direction for each test).

Each test piece is to be identified and must specify:

- the test piece direction in relation to the main longitudinal and transverse axis of the hull
- the layers' arrangement.

4.2.3 Types

For each set of test pieces to be tested, and for each result, the value to be recorded is the average for the number of tes pieces, provided that the minimum result is not less than 0,9 times the average. Otherwise, the Society decides which result is to be taken, on the basis of test conditions and the range of results.

In general, the following are to be performed:

- monolithic laminates: tensile tests and/or three points bending tests, measurement of density and percentage of reinforcement in weight
- sandwich laminates: three or four points bending tests; and for each skin, tensile tests, measurement of density and percentage of reinforcement in weight.

Bending tests are carried out with the load applied on the gel-coat side or on the opposite side. The side is to be chosen in agreement with the Society, in such a way that the test piece will break in a way representative of the relevant shell plating scantling.

The Tab 1 shows the types of tests to be performed, relevant standards and dimensions of test pieces and panels.

Additional or different tests, compared with those in Tab 1 may be requested, where the results are unsatisfactory, or in particular cases (e.g. structural components subject to high shear stresses).

Some specific mechanical tests may be requested by the Society where it is necessary to characterize particular laminating process such as structural gluing.

4.2.4 Reports

A report is issued on test results.

The values of the tests breaking bending moments and breaking tensile forces allow to estimate the test breaking stresses and strains and to compare them with the theoretical breaking criteria defined in Ch 12, Sec 3.

Table 1 : Testing of laminate test panels

	Test type - Standards	Quantity of test pieces	Size of test pieces **(1)**	Panels' number and dimensions (in mm)
Monolithic panels	Tensile test: ISO 527, or equivalent	- 5 lengthwise direction of panel - 5 crosswise direction of panels - 2 test pieces for calibration	Length = 400 mm Width = • 25 mm where thickness < 25 mm • 30 mm where thickness < 30 mm • etc.	All dimensions are described in standard ISO 1268, from item 1 to item 9. Each item corresponds to a way of laminating. **(1)**
	Bending test 3 points (ISO 14125 may be additionally used for determining the Interlaminar shear strength)	- 5 lengthwise direction of panel - 5 crosswise direction of panels - 2 test pieces for calibration	Length = 200 mm Width = • 25 mm where thickness < 25 mm • 30 mm where thickness < 30 mm • etc.	
	Measurement of density and reinforcement's content in weight: ISO 1172, (Nota2)	4 samples	30mm x 30mm	
Sandwich panels	Bending test 3 points (ISO 14125 may be additionally used for determining the Interlaminar shear strength)	- 5 lengthwise direction of panel - 5 crosswise direction of panels - 2 test pieces for calibration	Length = 1000 mm Width = 2 x thickness	Pre-cut test pieces to be delivered after Society agreement on sizes
	Skins' tensile test (for both skins): ISO 527, or equivalent	• 5 lengthwise direction of panel • 5 crosswise direction of panels • 2 test pieces for calibration		According to ISO. **(1)**
	Measurement of density and reinforcement's content in weight: ISO 1172, (Nota2)			

Note 1: Where both skins of the sandwich panel are fairly similar, tensile and density tests may be confined to one of the two skins.
Note 2: This test cannot be carried out when laminate tests panels are reinforced with carbon and/or para-aramid fibres.
Note 3: Equivalence of standards is to only assessment of the class Society.
Note 4: Equivalence of standards is to only assessment of the class Society.
(1) The Society may request additional tests with other sizes of test pieces.

4.2.5 Scope of test panel application

A test panel is produced in the following cases:

- Submission of a new composite hull for classification
- Changes in raw materials, arrangement of layers or manufacturing processes for new hull when the yard already classed similar hull
- At regular intervals, for mass-produced hulls. In this precise case, the frequency of production of test panels is to be agreed with the Society.

Note 1: Where a new type of model for classification is under construction in the yard, production of test panels may not be required, if the new model is considered to be fairly similar to a composite hull already classed by the Society, and which has not been in production for a too long period.