INTERNATIONAL STANDARD

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Small craft — Hull construction and scantlings —

Part 4: Workshop and manufacturing

Petits navires — Construction de coques et échantillons —

Partie 4: Ateliers de construction et fabrication

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 12215 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 12215-4 was prepared by Technical Committee ISO/TC 188, *Small craft*.

ISO 12215 consists of the following parts, under the general title *Small craft — Hull construction and scantlings*:

— *Part 1: Materials: Thermosetting resins, glass-fibre reinforcement, reference laminate*

— *Part 2: Materials: Core materials for sandwich construction, embedded materials*

— *Part 3: Materials: Steel, aluminium alloys, wood, other materials*

— *Part 4: Workshop and manufacturing*

— *Part 5: Design pressures, design stresses, scantling determination*

— *Part 6: Structural arrangements and details*

Small craft — Hull construction and scantlings —

Part 4: Workshop and manufacturing

1 Scope

This part of ISO 12215 specifies workshop conditions, material storage and handling, and requirements for the manufacturing of the craft. It applies, to small craft with a (L_H) length according to ISO 8666 of up to 24 m.

This part of ISO 12215 does not cover health and safety requirements.

NOTE The underlying reason for preparing this part of ISO 12215 is that workshop conditions have a significant influence on the mechanical short- and long-term properties of recreational craft and that the scantling determination according to ISO 12215-5 is based on conditions that are appropriate for the material used as well as the manufacturing process applied.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 12215. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 12215 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 8666:—[1)], *Small craft — Principal data*

ISO 12215-1:2000, *Small craft — Hull construction and scantlings — Part 1: Materials: Thermosetting resins, glass-fibre reinforcement, reference laminate*

ISO 12215-3:2002, *Small craft — Hull construction and scantlings — Part 3: Materials: Steel, aluminium alloys, wood, other materials*

3 Fibre-reinforced plastics (FRP) boat production

3.1 Workshop conditions

3.1.1 General

The buildings used for production and storage shall be of suitable construction, and equipped to provide the environment specified by the material manufacturer or supplier.

1) To be published.

To minimize contamination or impairment of the laminate, the production area shall be separate from the storage area and, wherever practicable, the various manufacturing processes shall be carried out in separate sections.

The workshop and equipment shall be properly maintained and kept in a clean condition, substantially free from debris, surplus material, and equipment that is not essential for the production process.

3.1.2 Temperature and humidity

Where a conventional manual lay-up or spray-up process is used, the moulding shop temperature shall be maintained within the limits specified by the resin manufacturer during lay-up and curing periods.

Should the temperature vary outside the specified limits, the boat builder shall establish with the resin manufacturer that the resulting laminate will meet the requirements upon which scantlings and design are based.

The relative humidity in the moulding shop shall be maintained within the limit recommended by the material manufacturers.

Materials shall be brought up to the workshop temperature prior to use.

The temperature and humidity shall be monitored in appropriate locations, and records shall be kept.

3.1.3 Ventilation

Adequate ventilation shall be provided in the laminating area, in order to minimize accumulation of monomer fumes in the mould. The ventilation shall not significantly reduce the surface temperature of the mould or laminate.

The design of the ventilation system shall take account of the size of the laminating shop, possible subdivision and the amount of resin under cure.

The ventilation arrangements shall not cause excessive evaporation of the resin monomer. Precautions shall be taken to ensure freedom from draughts.

3.1.4 Dust control

Provisions shall be made to minimize harmful accumulation of dust on moulds and laminates.

3.1.5 Illumination

Provisions shall be made to avoid any harmful effects on the resin cure due to direct sunlight or artificial lighting.

3.2 Material storage and handling

3.2.1 General requirements

Storage areas shall be arranged and equipped in such a way that the material manufacturer’s requirements for storage and handling can be followed.

The procedures for the reception, verification against certificates of conformity, storage and handling of materials shall be detailed in the conformity assurance procedures provided by the boat builder (see clause 10) to ensure that the materials suffer no contamination or degradation and carry adequate identification at all times.

Storage shall be arranged so that wherever possible materials are used in order of receipt.

Structural parts shall be manufactured from materials that have not passed the material manufacturers’ date of expiry.

Materials found to be defective or not in compliance with the specifications of raw-material supplier(s) shall be rejected unless treated in accordance with the conformity assurance procedure, provided by the boat builder.

Unused resin and ancillary materials exposed to the workshop atmosphere shall not be returned to the parent stock or bulk storage.

3.2.2 Resin

Resins shall be stored under controlled conditions in accordance with the resin manufacturer's requirements.

Where a resin contains an ingredient that can settle within the resin system, it is the builder's responsibility to ensure that the resin manufacturer's recommendations for mixing and conditioning are complied with prior to use.

3.2.3 Catalysts and accelerators

Catalysts and accelerators shall be stored according to the material manufacturer's requirements.

3.2.4 Fillers and additives

Fillers and additives used in the moulding process shall be stored in closed containers to protect them from dust and humidity.

3.2.5 Reinforcing and core materials

Reinforcing and core materials shall be stored in clean and dry conditions, in accordance with the material manufacturer's recommendations.

3.3 Moulds

3.3.1 Construction

Moulds shall be constructed of a suitable material and adequately stiffened to maintain their shape and fairness of form.

The materials used in the construction of moulds shall not adversely affect the resin cure.

3.3.2 Preparation

Moulds shall be cleaned, dried and in place so that they stabilize at the workshop temperature before the release agent is applied.

The release agent shall be compatible with the mould surface, the resins applied in the laminating process and with mould release films used previously.

Release agents containing silicon shall not be used.

NOTE Release agents containing silicone oil may interfere with adhesion or secondary bonding when using common resin types.

3.4 Resin preparation

The requirements of the resin manufacturer shall be followed.

Where blended resins are used, test specimen(s) shall be made to ensure that the blended resin is suitable for the laminating process.

Where the boat builder wishes to modify resin with additives outside the resin manufacturer's specification, the boat builder shall conduct tests to verify compliance with Table 3 of ISO 12215-1:2000.

3.5 Laminating process

3.5.1 Manual lay-up

The material type and unit weight of the first fibre reinforcement layer shall be chosen to provide for adequate penetration of the reinforcement layer by the resin system used and reduce the effect of hydrolytic attack.

The lay-up sequence and degree of resin cure between plies shall be in accordance with the resin manufacturer's recommendation. Where the degree of cure exceeds these recommendations, the surface shall be treated.

Moulds shall be arranged or access provided so that each part of the mould can be reached with the tools used to ensure consolidation and de-aeration of the laminate during lay-up.

3.5.2 Spray lay-up

Spray lay-up of resin and/or reinforcement fibres shall be limited to applications where, in general, a specified even thickness of the sprayed laminate can be achieved.

Consideration shall be given to

— exothermic heat by excessive wet laminate thickness,

— sagging or drainage of the laminate, and

— de-aereation.

The weight of glass reinforcement to be deposited between resin/glass consolidation depends upon the complexity of the mould.

In general, this shall not be more than 1 150 g/m^2 of glass fibres, unless it can be demonstrated that a satisfactory laminate can be achieved with a greater glass reinforcement weight.

The uniformity of the laminate and glass content shall be checked at regular intervals.

Where the back-up layer behind the gelcoat is sprayed-up, the type and length of the fibres shall ensure that no wicking effect can occur.

The spray equipment shall be calibrated and shall be checked for the desired setting for the resin/catalyst and resin/reinforcement fibre ratios at the beginning of each working day. To ensure that the lay-up is within tolerances, the settings shall be monitored.

3.5.3 Closed moulding

When closed moulding is applied, the system shall be designed to ensure the correct distribution of resin in the laminate.

3.5.4 Pre-impregnated laminates

Pre-impregnated laminates shall be stored, used and cured in accordance with the material manufacturer's requirements.

3.6 Surface coating

3.6.1 Coating material

Gelcoat or another suitable coating, which may be the laminating resin when designed for this purpose, shall be applied to provide some protection from solar radiation, hydrolytic attack and abrasion. Where gelcoat is used, the first layer of reinforcement shall be applied according to the resin manufacturer's specification and as soon as the gelcoat has adequately cured.

3.6.2 Spray surface coating

The spray equipment shall be calibrated and shall be checked for the desired settings for the resin/catalyst ratios and the spray pattern at the beginning of each working day or prior to the start of single-part work to ensure consistent application.

3.7 Manufacturing requirements, sandwich construction

3.7.1 Sandwich construction using female moulds

3.7.1.1 Core surface cavities and other irregularities shall be removed or coated with filler, resin or sandwich adhesive according to the material manufacturer’s specification and depending on the following skin lay-up. When using scored core material, a sufficient amount of resin or adhesive shall be used in the bond to fill the gaps.

3.7.1.2 When bonding core material to a wet laminate, sufficient resin shall be in or on the laminate to achieve a bond between the laminate and core material without resin deficiency of the laminate.

3.7.1.3 The materials shall be kept in contact while curing to ensure a structurally sufficient bond and to avoid air entrapment.

3.7.1.4 Deviations from these procedures may be made, provided that the structural requirements of ISO 12215-5 are met.

3.7.2 Sandwich construction with male moulds

3.7.2.1 Joints, scores and voids in the core material shall be filled or fixed to each other before the skin laminate is applied.

3.7.2.2 When laying the core material, it shall not be bent or deformed to such an extent that the properties of the core are adversely affected.

3.7.2.3 Irregularities on the core surface and the joints shall be removed.

3.7.2.4 The core surface shall be primed where required before the laminate is applied.

3.8 Laminate curing

3.8.1 Open-mould process

The laminate cure schedule shall follow the resin manufacturer's requirements and shall be documented.

The curing schedule for sandwich laminates shall take into account the thermal influence of the core material and the possible slower initiation of the cure due to thin laminates.

If the resin requires higher post-cure temperatures than ambient temperature, this process shall be documented.

Post-curing at an elevated temperature shall not commence until the laminate has stabilized.

The post-cure temperature shall be compatible with the temperature limits of the release agent and shall not adversely effect the gelcoat, the single skin or sandwich laminate.

3.8.2 Closed-mould process

The curing schedule for the closed-mould technique shall take into account the thermal influence of material, mass and construction of the mould.

4 Metal craft production, steel and aluminium

4.1 Storage and handling

4.1.1 Suitability

The materials used in the production of craft built of steel or aluminium alloys shall be in accordance with the requirements of ISO 12215-3.

4.1.2 Identification and marking

4.1.2.1 Materials shall be fully identifiable throughout the storage and production process.

4.1.2.2 The builder shall ensure that each delivery of material is accompanied with the appropriate documentation. He shall further check that markings on incoming material conform with the purchase order.

The builder shall maintain purchasing documents containing a clear description of material ordered for hull construction referring to the appropriate standards or specifications.

4.1.2.3 Non-conforming material shall be separated from the acceptable material.

4.1.2.4 Where materials are found to be defective, they shall be disposed of in accordance with the builder´s conformity assurance procedure.

4.1.2.5 The builder shall establish and maintain a procedure to ensure that material and consumables used in the construction process are identified (by colour-coding and/or marking or any other means, as appropriate) from arrival in the yard through to fabrication in such a way as to enable the type and grade to be readily recognized.

4.1.3 Storage

4.1.3.1 Materials shall be stored in accordance with the material manufacturer's requirements. Storage arrangements shall be such as to prevent deterioration through adverse environmental conditions and poor handling.

4.1.3.2 Welding consumables shall be stored in suitable conditions to maintain them in accordance with the material manufacturer's recommendations.

4.2 Workshop conditions

During construction the craft shall be suitably protected, from weather and climatic influences, which may have an adverse effect on the quality of the completed craft.

4.3 Construction

4.3.1 Preparation

Steel shall be suitably cleaned and cleared of millscale and rust prior to fabrication of the small craft. The preparation of materials (e.g. cutting, bending, forming) shall follow recognized industry practice and shall be such as to ensure that the mechanical properties of the material are not adversely affected.

4.3.2 Procedure for welded construction

4.3.2.1 General

The requirements of this subclause are applicable to steel and aluminium alloys using appropriate welding processes.

4.3.2.2 Documentation

Details of welded connections of the main structural members shall be contained in construction plans and/or descriptions.

4.3.2.3 Welding equipment

The welding plant and equipment shall be suitable for the purpose intended.

4.3.2.4 Welder qualifications

The builder shall ensure that welding operators are qualified for the type of work they are engaged in. The responsibility for selection, training and testing of welding operators rests with the builder, who shall qualify them according to suitable standards or satisfactory practice.

4.3.2.5 Welding environment

Adequate protection, such as screening, shall be provided where welding is to be carried out in wet, windy or cold weather. In cold or very humid conditions, it may be necessary to preheat the work to prevent too rapid cooling of the weld.

4.3.2.6 Preparation for welding

The preparation of plate edges shall be accurate and free from harmful defects. Joints shall be properly fitted up, or aligned without using excessive force, before welding.

Parts shall be set up and welded in such a way that contraction stresses are kept to a minimum.

4.3.2.7 Cleanliness

The surfaces to be welded shall be clean, dry and free from grease and other contaminants which might adversely affect weld quality.

Where a primer has been used after surface preparation and prior to fabrication, the composition of the primer shall have no detrimental effect on the subsequent welding work.

4.3.2.8 Acceptance criteria

Finished welds shall be sound and free from cracks and substantially free from other harmful defects.

Visual inspection of all welds shall be carried out after finishing the work. Critical areas or connections may require additional examination.

Weld defects shall be removed and repairs carried out.

4.4 Steel/aluminium transition joints

4.4.1 Explosion-bonded composite transition joints shall be used for connecting aluminium to steel. These assemblies shall be used in strict compliance with the joint manufacturer´s specification.

4.4.2 Bimetallic joints, where exposed to sea water or used internally within wet spaces, shall be suitably protected to prevent galvanic corrosion.

4.5 Adhesive bonding of structure

4.5.1 The adhesive manufacturer´s recommendations in respect to the jointing system, comprising surface preparation, the adhesive, bonding, and curing processes and environmental conditions, shall be strictly followed.

4.5.2 Where adhesive bonding of any load-bearing structure is used, test samples shall be manufactured under workshop conditions to demonstrate that the bonded connection develops its intended strength.

4.5.3 The method used to bond joints shall be documented so that the process is repeatable after the procedure has been verified.

4.5.4 Bonded joints shall be designed to avoid tension on the joints which may cause peeling forces tending to open the joint, unless tests and calculations show that the joint has sufficient strength.

4.5.5 Glued joints shall be resistant to, or protected against, sunlight (UV, heat, etc.) and environmental effects or cleaning agents normally encountered in the manufacture or the use of the craft.

4.6 Steel/wood and aluminium/wood connection

To minimize corrosion of steel or aluminium in contact with wood in a damp or marine environment, the surfaces in contact shall be protected in accordance with good practice. Surfaces in contact shall be primed and painted, or coated with a substantial thickness of a suitable sealant.

4.7 Surface coating

Metal shall be given adequate protection for its intended use by an adequate surface treatment and/or coating, as necessary.

5 Aluminium craft production, specific requirements

5.1 Building environment

Aluminium shall not be welded when damp or wet in order to avoid hydrogen inclusions in the welds.

5.2 Storage

Aluminium shall be stored in dry places, clear of the ground. Contact with other stored materials shall be avoided.

5.3 Tools

Where a builder is working with both aluminium and steel, the tools directly in contact with the metal used in aluminium production shall be clearly marked (e.g. by colour) for use with aluminium only.

5.4 Galvanic action

Where bimetallic connections are made, involving dissimilar metals, measures shall be taken to prevent galvanic action.

5.5 Corrosion prevention

Areas of the hull structure that are permanently or temporarily submerged shall be protected by means of coating or cathodic protection.

6 Wooden boat production

6.1 Workshop conditions

The premises used for production and storage shall be suitable, and equipped to provide the conditions necessary for fault-free bonding by adhesives. This shall enable the builder to monitor, and if necessary control, temperature, humidity and other environmental conditions during manufacturing so as to avoid changes during manufacture.

The workshop and equipment shall be maintained in a clean and efficient condition.

6.2 Material

6.2.1 Material storage

Timber shall be stored in dry and well-ventilated premises where it is protected from direct sunlight and excessive moisture. It shall be stored horizontally, each plank or layer being separated from the other to achieve air circulation.

6.2.2 Glues, adhesives

Adhesives shall be suitable for the intended purpose. The bond's mechanical properties and life shall exceed that of the glued wood.

Adhesives shall be stored as specified by the manufacturer of these materials in their original containers. They must not be used after their expiry date.

6.2.3 Fastening elements

Fastening elements for load-bearing parts of the construction, e.g. nails, screws and bolts shall be corrosion resistant or hot-dipped galvanized.

6.3 Manufacturing

6.3.1 General

Manufacturing shall take place in an environment that takes into account the requirements and limitations specified by the manufacturer of the material (e.g. glue, resin or paint).

6.3.2 Glued connections

The moisture content of the wood shall be checked before gluing. The moisture content shall not exceed that which permits full joint strength.

Areas to be glued shall be free from any contamination that might impair the strength of the bond.

6.3.3 Prevention of deterioration

Wooden craft shall be constructed in such a way that water cannot collect in areas where it cannot be drained.

They shall also be constructed in such a way that natural ventilation is promoted to all areas of the craft.

6.4 Surface treatment

A protective coating or surface treatment shall be applied to finished surfaces not intended to be left bare, for example teak decks. Any coating or treatment shall not adversely react with the adhesives, reduce the mechanical property of the joint or have a detrimental effect on the wood itself.

7 Boat production using other materials

The manufacturing of small craft using other materials than those described in clauses 3 to 6 shall follow similar procedures, especially with regard to

— material manufacturer's requirements,

— suitability for the purpose intended,

— identification, storage and handling of materials,

— workshop conditions,

— suitable construction procedures, and

— acceptance criteria.

8 Qualification of personnel

8.1 Personnel requirements

The construction of small craft shall only be carried out by personnel with the necessary boat building skills for the specific materials used and manufacturing processes applied.

8.2 Responsibility

The person responsible for proper execution of the work shall have the appropriate knowledge verified by certificates, or professional experience in his specific job over several years.

9 Final inspection

When the structural work is completed, it shall be inspected and a report produced which shall be signed by the responsible person(s) and be added to the technical documentation of the craft.

10 Conformity assurance

10.1 The builder shall establish a conformity assurance procedure which takes into account

— the relevant construction plans,

— the materials used in the construction process,

— the complexity of the products,

— the manufacturing process, and

— the overall conditions of the manufacturing premises.

10.2 For each product or series of products, a documentary record shall be kept which contains at least the following information:

— data sheets for materials, where relevant for the structural integrity of the craft used in the production, including the material manufacturers' requirements and test reports (if any);

— records of the environmental conditions under which the manufacture of the product has taken place;

— a record of structural faults, remedial or special actions;

— a record of final inspection and/or testing of the product.

10.3 (A) qualified responsible person(s) shall be named for the production or parts of the production who shall sign the records as required in 10.2.

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