RULES FOR THE CLASSIFICATION AND CONSTRUCTION

PART 1. SEAGOING SHIPS

VOLUME XIV
RULES FOR NON–METALLIC MATERIALS
2014 EDITION

BIRO KLASIFIKASI INDONESIA

RULES FOR THE CLASSIFICATION AND CONSTRUCTION

PART 1. SEAGOING SHIPS

VOLUME XIV
RULES FOR NON–METALLIC MATERIALS
2014 EDITION

Biro Klasifikasi Indonesia
Jl. Yos Sudarso No. 38-40, Tanjung Priok
Jakarta 14320
www.bki.co.id
rules@bki.co.id

This page intentionally left blank

Foreword

These Rules amends Rules for Non Metallic Materials – 2006 edition , which is consist of three chapter, as follows:

Chapter 1 : Fibre Reinforced Plastics and Bonding.
The requirements in this chapter apply to all materials used during production and/or repair of component from FRP.

Chapter 2 : Wooden Materials.
The timber used in boatbuilding shall be fulfill the requirements in this chapter, as well as for core materials of sandwich laminate.

Chapter 3 : Guidelines for Elastomeric Adhesives and Adhesive Joints
Elastomeric adhesive used to bond parts and components of metal, plastic and other materials shall be meet the requirements in this chapter.

Amendments in these Rules are indicated with underlines. The amendments include reference standards, table of requirement, terms, and deletion of some outdated paragraph which the changes are according to the latest national and international standards, recent technology and also inputs from the stake holder.

BKI welcomes comments and suggestion for improvement in these Rules. Comments or suggestions can be sent electronically to rules@bki.co.id.

This page intentionally left blank

Table of Contents

Page

Foreword iii
Table of Content v
Rules Amendment Notice vii

CHAPTER 1 - FIBRE REINFORCED PLASTICS AND BONDINGS

Section 1 - Requirements for Materials and Production ..... 1 / 10
A. Definitions ..... 1 / 10
B. Materials ..... 1 / 10
C. Approval of Materials ..... 4 / 10
D. Requirements for Manufacturers ..... 4 / 10
E. Regulations for Processing ..... 6 / 10
F. Manufacturing Surveillance ..... 9 / 10

Section 2 - Inspection and Testing of Fibre Composite Materials ..... 1 / 11
A. Requirements ..... 1 / 11

Section 3 - Repair of Components ..... 1 / 4
A. General ..... 1 / 4
B. Procedure ..... 2 / 4
C. Documentation ..... 4 / 4
D. Enclosures ..... 4 / 4

CHAPTER 2 - WOOD

Section 1 - Requirements for Materials, Bonding Methods and Wood Protection ..... 1 / 22
A. General ..... 1 / 22
B. Types of Wood and Classifications ..... 1 / 22
C. Boatbuilding Plywood ..... 4 / 22
D. Plywood for Aircrafts ..... 13 / 22
E. Joining of Wood Materials ..... 21 / 22
F. Wood Protection ..... 22 / 22

Section 2 - Requirements for the Core Materials of Sandwich Laminates ..... 1 / 1
A. Cross-Cut Balsa Wood ..... 1 / 1

CHAPTER 3 - GUIDELINES FOR ELASTOMERIC ADHESIVES AND ADHESIVE JOINTS

Section 1 - Requirements for the Adhesives and Adhesive Joints ..... 1 / 6
A. General ..... 1 / 6
B. Approval of the Adhesives ..... 2 / 6
C. Requirements for the Adhesive-Processing Shops and the Personnel ..... 2 / 6
D. Execution of the Bonding ..... 2 / 6
E. Manufacturing Surveillance at the Applicator ..... 4 / 6

Section 2 - Approval of Elastomeric Adhesives ..... 1 / 3
A. Requirements ..... 1 / 3

Annex A - Applicable Standards and Guidelines ..... A-1 / 1
A. Applicable Standards and Guidelines for Section 1 ..... A-1 / 1
B. Applicable Standards and Guidelines for Section 2 ..... A-1 / 1

Annex B - Example for a Documentation Accompanying Each Stage of Production / Procedure Test ..... B-1 / 4
A. Documentation ..... B-1 / 4
B. Check of the Bonded Joints (in the Case of Documentation Accompanying each Stage of Production) ..... B-3 / 4
C. Testing of the Bonded Joints (in the Case of a Procedure Test) ..... B-4 / 4

Rules Amendment Notice

These pages contain amendments within the following Sections of the Rules for Non Metallic Materials, 2014 Edition.

These amendments are effective from August, 1st 2014

Paragraph	Title/Subject	Status/Remarks
CHAPTER 1 - FIBRE REINFORCED PLASTICS AND BONDINGS		
Section 1 D.1.1 – 1.3	No Title	To add the requirment for manufacture approval
Section 1 E.5.1	No Title	To add the temperature requirement during curing time
Section 1 E.6	Adhesive Bonding	To add the requirement for adhesive bonding
Section 1 F.2.1	No Title	To add the requirement for material properties verification by inspection documents acc. to EN 10204
Section 1 F.2.2	No Title	To add the incoming inspection for materials
Section 1 F.2.3	No Title	To add the requirement for storage of material
Section 1 F.3	Production Surveillance	To add new requirement for prodution surveilance
Section 2 A.3.4.7	No Title	To add new requirement for modulus elasticity of carbon fibres
Section 2 Table 2.1	Coefficients for the determination of the minimum properties	To change the minimum requirement for mechanical properties
Section 2 A.5.3.2.	No Title	To add requirement for balsa wood adhesion
Section 2 A.6.4.1	No Title	To add requirement for dimensional stability under heat
Section 2 A.6.5.1	No Title	To add requirement for temperature of dimensional stability under heat
Section 2 A.6.5.2	No Title	To add requirement for strain in creep for adhesive layer thickness of 0.5 mm and 3 mm

Paragraph	Title/Subject	Status/Remarks
Section 3 A.1.5	No Title	To add the reference for shop approval
Section 3 A.2.6	No Title	To add an exception of using original thermosetting resin for repair
Section 3 B.1.2	No Title	To add the constant value of x in the formula and change the requirement for permissible shear stress
CHAPTER 2 - WOOD		
Section 1 Table 1.1	Plywood strength groups	To change the durability requirement for Makore and Douka timber type
Section 1 C.6.1	No Title	To add requirement for number of defect present
Section 1 C.10.5.4	No Title	To change reference standard
Section 1 C.10.6.3.1	No Title	To change reference standard
Section 2 A.1.1	No Title	To change reference section
Section 2 A.2.2	No Title	To change reference standard
CHAPTER 3 - GUIDELINES FOR ELASTOMERIC ADHESIVES AND ADHESIVE JOINTS		
Annex A Table A.1	Applicable Standards and Guidelines for Section 1	To revise the date of issue of standards
Annex A Table A.2	Applicable Standards and Guidelines for Section 2	To revise the title and date of issue of standards

RULES FOR THE CLASSIFICATION AND CONSTRUCTION

PART 1. SEAGOING SHIPS

VOLUME XIV
RULES FOR NON–METALLIC MATERIALS
2014 EDITION

CHAPTER 1 - FIBRE REINFORCED PLASTICS AND BONDINGS

Biro Klasifikasi Indonesia
Jl. Yos Sudarso No. 38-40, Tanjung Priok
Jakarta 14320
www.bki.co.id
rules@bki.co.id

This page intentionally left blank

Table of Contents

CHAPTER 1 - FIBRE REINFORCED PLASTICS AND BONDINGS

Section 1 - Requirements for Materials and Production ..... 1 / 10
A. Definitions ..... 1 / 10
B. Materials ..... 1 / 10
C. Approval of Materials ..... 4 / 10
D. Requirements for Manufacturers ..... 4 / 10
E. Regulations for Processing ..... 6 / 10
F. Manufacturing Surveillance ..... 9 / 10

Section 2 - Inspection and Testing of Fibre Composite Materials ..... 1 / 11
A. Requirements ..... 1 / 11

Section 3 - Repair of Components ..... 1 / 4
A. General ..... 1 / 4
B. Procedure ..... 2 / 4
C. Documentation ..... 4 / 4
D. Enclosures ..... 4 / 4

This page intentionally left blank

Section 1

Requirements for Materials and Production

A. Definitions

1. Fibre-reinforced plastics (FRP)

Heterogeneous materials, consisting of a thermosetting resin as the matrix and an embedded reinforcing material.

2. Thermosetting resin

Two-component mixture consisting of resin and hardener as well as possible additives.

3. Reinforcing materials

Materials generally in the form of fibre products which are embedded in a matrix in order to improve certain properties. In doing so, fibres of different materials displaying isotropic or anisotropic properties are processed in the form of semi-finished textile products (mats, rovings, fabrics, non-wovens). For special requirements, mixtures of different fibre materials are also used (hybrids).

4. Prepreg

Reinforcing material which is pre-impregnated with a thermosetting resin which can be processed without any further addition of resin or hardener.

5. Laminate

A moulded part which is manufactured by placing layers of reinforcing material on top of each other together with the thermosetting resin.

6. Sandwich laminate

Two laminate layers connected together by means of an intermediate core of a lighter material.

B. Materials

1. Thermosetting resin

Depending on the purpose, and consequently the requirement, a distinction is made between laminating resin and coating resin. Compatibility shall be demonstrated for the combination of gelcoat and laminating resin if the basic formulation of the resins are not the same.

1.1 Gelcoat and Topcoat resin

Gelcoat and topcoat resins shall protect the surface of the laminate from mechanical damage and environmental influences. Therefore, in a cured stage, the resin is to have a high resistance to existing media (e.g. fuel, river and sea water), to maritime and industrial environments), and to abrasion, in addition to low water absorption capabilities. Thixotropic agents and colouring pigments are the only permitted additives for gelcoat resins. In topcoat resins, additives for low styrene evaporation are also permitted.

1.2 Laminating resin

Laminating resins shall have good impregnation characteristics when being processed. In a cured stage, they shall be resistant to fuels, river and sea water, and shall exhibit a high resistance to ageing. Furthermore, adequate resistance to hydrolysis shall be ensured when used with permissible additives and filling materials. When using unsaturated polyesters (UP) as the resin, the resistance to hydrolysis shall be significantly higher than that of standard UP resin (for example through the use of a resin with an isophtalic acid basis).

1.3 Additives

1.3.1 All additives (catalysts, accelerators, filling materials, colouring pigments etc.) shall be suitable for the thermosetting resin and shall be compatible with it as well as the other additives, such that a complete curing of the resin can be ensured. The additives shall be dispersed carefully throughout the resin, in accordance with the guidelines of the manufacturer.

1.3.2 Catalysts, which initiate the hardening process, and accelerators, which control the working time (pot life, gel-time) and the cure time, shall be used in accordance with the processing guidelines provided by the manufacturer. For cold-setting systems, catalysts shall be proportioned in such a way that complete curing is ensured between temperatures of 16°C and 25°C. Cold-setting systems that are to cure at temperatures outside of this range, as well as warm- curing systems, may be used after consultation with BKI Head Office.

1.3.3 Filling materials shall not significantly impair the properties of the cured resin. The type and quantity of the filling materials shall be approved by BKI Head Office and shall not lead to non-compliance with the minimum properties of the resin (see Section 2, A.2.5). In general, the proportion of filling materials in the laminating resin compound shall not exceed 12 % by weight (including a maximum of 1.5 % by weight of the thixotropic agent). If a smaller value is specified by the manufacturer, this value shall apply. The proportion of thixotropic agent in the gelcoat resin compound shall not exceed 3 % by weight. Laminates used for fuel and water tanks shall not contain filling materials.

1.3.4 Colouring pigments shall be climate-proof and consist of inorganic or non-fading organic dyes. The maximum permissible proportion shall not exceed the value specified by the manufacturer; if no value is specified, then it shall not exceed 5 % by weight.

2. Reinforcing materials

2.1 Various types of reinforcing materials with filaments of glass, carbon and aramide are available:

Roving : A large number of parallel filaments placed together with or without twisting.

Mat : Irregular layering of continuous filaments (fleeces), or chopped rovings (minimum 50 mm long) which are joined together by means of a binder.

Fabric : Rovings woven together by means of the weaving techniques used in the textile industry, such as binding cloth, satin, body, atlas etc. Different materials and/or filament thicknesses are possible for warp and weft.

Non-woven fabric : Unidirectional layers of fibres which are laid on each other in an arbitrary manner. The layers are fixed by thin fibre strands, either together or on mats. Different materials and/or filament thicknesses are possible in the individual layers.

2.2 Fibre surface treatment with sizing, coupling agents or finish shall be matched to the thermosetting resin, in order to ensure adequate material properties, also under the influence of media.

2.3 Only low-alkaline aluminium boron silicate glass may be used for glass fibres (alkali oxide content $\leq$ 1%), e.g. E-glass in accordance with DIN VDE 0334/Part 1, 9.72, Section 4.

3. Core materials for sandwich constructions

3.1 It shall be demonstrated that the core materials used are suitable for the intended purpose. They shall not impair the curing of the laminating resin.

3.2 The joining surfaces of local reinforcements made of metallic materials (e.g. inlets, connections) shall be cleaned in the same manner as for a gluing process, in order to ensure optimal bonding (see DIN 53281:2006-06).

3.3 Core materials other than those listed below may be used, provided that they are suitable for the intended purpose and that this is accepted by BKI Head Office by beforehand.

3.4 Rigid foam materials

Rigid foam materials which are used as core material for sandwich laminates, or as shear webs, shall be of a closed-cell type and have high resistance against the laminating resin or the adhesive, as well as against ageing, fuels, river and sea water. A low water absorption capability is required, together with a minimum apparent density of 60 kg/m³.

It shall be ensured that the allowable temperature of foam material is not exceeded during the curing reaction (exothermic reaction).

3.5 End-grained balsa wood

End-grained balsa wood used as core material for sandwich laminates shall fulfill the following requirements. It shall:

- have immediately been treated after felling against attack by fungi and insects,
- be sterilized and homogenized,
- be kiln-dried within 10 days after felling, and
- have an average moisture content of maximum 12%.

4. Prepregs

Fibre reinforcements pre-impregnated with laminating resin shall satisfy the requirements placed on their components. In addition, a minimum resin volume content of 35 % by volume shall be ensured, as well as adequate tack at the processing temperature.

5. Adhesives

5.1 When bonding fibre-reinforced plastics together, or with other materials, only solvent-free adhesives shall be used. Preference shall be given to two-component reaction adhesives, if possible with the same basis as the laminating resin.

5.2 Laminates shall only be bonded in the cured state. Hot-setting adhesives generally attain a higher strength; however, the maximum allowable temperature of the materials to be bonded shall not be exceeded. This applies especially when using single-component hot-melt adhesive.

5.3 The adhesives shall be used in accordance with the processing guidelines issued by the manufacturer. They shall not affect the materials to be bonded and shall exhibit a high resistance to humidity and ageing. The influence of the operating temperature on the adhesive strength shall be small.

5.4 Adhesives shall be usable within a minimum temperature range of -20° to +60°C.

C. Approval of Materials

1. All materials to be used during production of components from FRP shall first be assessed and approved by BKI. Approval by other organizations can be recognized following agreement by BKI, provided that the tests required for approval are in accordance with BKI requirements.

2. The manufacturer and/or supplier of the material shall apply to BKI Head Office for approval.

3. Approval is granted if the material fulfils the requirements of BKI. For this purpose, specific tests are necessary, and they shall either be carried out under supervision of BKI or the results shall be documented in the report of a recognized testing institute. The respective test criteria are given in Section 2, A.2.4.3.

4. Before production starts, the required material approvals shall be submitted to BKI Head Office and/or BKI Branch office. If no approvals, or not all required approvals have been obtained, then as an exception and following agreement with BKI Head Office, proof of the properties of the basic material can be demonstrated as part of material testing of the component laminate.

5. The packaging or wrapping material shall bear a reference to the approval.

D. Requirements for Manufacturers

1. General

1.1 Manufacture of FRP-components shall only be performed by workshops which are approved by BKI for the manufacture of components made from fibre-reinforced thermosetting resins.

1.2 The manufacture of FRP-components shall only be carried out by persons with sufficient professional knowledge. This professional knowledge shall in general be verified by certificates of the corresponding training courses. If such certificates are not available, the minimum requirement shall consist of training completed for a technical profession, in conjunction with internal training and several months of experience.

1.3 The shop approval is granted by BKI Head Office on the basis of the information to be submitted with Form F12.3.02 and the report submitted by the BKI Surveyor (F22.2.03). The form deals with the following points:

- general information on the shop
- personnel
- internal quality management
- incoming inspection
- storage of the materials in the shop and during field work
- mechanical processing capabilities
- production equipment

1.4 All manufacturing facilities, store-rooms and their operational equipment shall fulfill the requirement of the responsible safety authorities and professional employers liability insurance associations. The manufacturer is exclusively responsible for compliance with these requirements.

1.5 The danger of contamination of laminating materials shall be minimized through separation of production facilities from store-rooms.

1.6 During laminating and bonding in the laminating shop, no dust-generating machinery shall be operated nor any painting or spraying operations carried out. As a matter of principle, such work shall take place in separate rooms.

2. Laminating workshops

2.1 Laminating workshops shall be closed spaces capable of being heated and having supply and exhaust ventilation. During laminating and curing, a room temperature of between 16 °C and 25 °C and a maximum relative humidity of 70 % shall be maintained, provided that the manufacturer of the laminating resin compound does not specify otherwise.

2.2 In order to control the climatic conditions, thermographs and hydrographs shall be provided. The equipment shall be set up following agreement with BKI, their number and arrangement depending on operational conditions. The equipment shall be calibrated in accordance with statutory regulations. The recordings shall be kept for at least 10 years and submitted to BKI on request.

2.3 Ventilation facilities shall be arranged in such a manner that no inadmissible amounts of solvents are removed from the laminate, and also that no inadmissible workplace concentrations (MAC values) occur.

2.4 The workplaces shall be illuminated adequately and suitably, but at the same time precautionary measures shall be taken to ensure that the controlled curing of the laminating resin compound is neither impaired through sunlight nor lighting equipment.

3. Storage-rooms

3.1 Laminating resins shall be stored in accordance with the manufacturer's instructions. If no such instructions are provided, then they shall be stored in dark, dry rooms at a temperature between 10°C and 18°C. The temperature of the storage-rooms shall be recorded continuously by means of thermographs.

3.2 Prepregs shall be stored in special cold-storage rooms in accordance with the manufacturer's instructions.

3.3 Hardeners, catalysts and accelerators shall be stored separately in well-ventilated rooms in accordance with the manufacturer's instructions. If no instructions are provided, they shall be stored in dark, dry rooms at temperatures between 10 °C and 18 °C.

3.4 Reinforcing materials, fillers and additives shall be stored in closed containers, in dry and dust-free conditions.

3.5 Storage shall be arranged in such a way that the identification of the materials, their storage conditions and maximum period of storage (expiry date) as prescribed by the manufacturer are clearly visible. Materials whose duration of storage exceeds the expiry date shall be removed immediately from the stores.

3.6 Quantities of materials due to be processed shall be brought to the production shops as early as possible to ensure complete adjustment to the processing temperature ($\Delta T \leq 2°$ C), with the containers remaining closed.

3.7 Materials taken from the stores and partially used shall only be replaced in the stores in special cases (e.g. hot-curing prepregs) and with the consent of BKI.

E. Guidelines for Processing

1. General

1.1 As a matter of principle, only materials approved by BKI shall be used. In addition to the choice of suitable and approved materials, special care shall be taken when working with them because of the great influence on the properties of the product.

1.2 For the preparation and processing of the resin compounds and reinforcing material, these Rules, the instructions issued by the material manufacturers and the regulations of the local authorities shall also be observed.

1.3 Resin, hardener and resin additives shall be mixed in such a way as to ensure a uniform distribution and to minimize the amount of air introduced into the mixture as far as possible. A degassing of the resin compound may be necessary in individual cases.

1.4 During lamination, the processing time of the prepared resin compound specified by the manufacturer shall not be exceeded. If such a time is not specified, the pot-life shall be determined by means of a preliminary test and the processing time then established in consultation with BKI.

1.5 It is not possible to cover all types of moulds and processing methods in detail. Deviations are therefore possible for special cases with the consent of BKI.

2. Requirements for moulds

2.1 The moulds shall be made of a suitable material that, on the one hand, has adequate stiffness to prevent inadmissible deformations while laminating or curing, and on the other hand has no influence on the curing of the laminate. Moulds made of FRP may be used only after complete curing and subsequent tempering.

2.2 In the case of moulds for products which are made using vacuum bags, absolute air tightness of the mould shall additionally be ensured.

2.3 The surface of the moulds shall be as smooth as possible and shall have no sharp edges. The mould shall be designed in such a way as to permit flawless removal of the product from the mould.

2.4 Before commencing with the laminating, the surface of the components shall be treated with a sufficient quantity of a suitable release agent and brought up to the temperature required for lamination. The surfaces shall be dry and free of dust. It is not permissible to use release agents with a silicon base.

3. Building up the laminate

3.1 If the surface protection is to be achieved by providing a gelcoat, then the gelcoat resin compound shall be applied with a uniform thickness of between 0,4 and 0,6 mm, using a suitable process.

3.2 The first laminate layer shall be applied as soon as possible after application of the gelcoat. A fibre mat or fabric with low weight per unit area and a high resin content shall be used (e.g. for glass fibres: a maximum of 450 g/m² and a maximum of 30 % glass by weight).

3.3 The laminate shall be built up in accordance with the approved technical documentation, whereby BKI shall be consulted about the method. Air shall be adequately removed from the reinforcing layers and these layers shall be compacted in such a manner to ensure that the required proportion of resin is achieved. Resin enrichment shall be avoided.

3.4 The maximum thickness of the material that can be cured at one time is determined by the maximum permissible heat development. In the case of vacuum bagging, as a rule, the decisive factor is the maximum number of layers from which air can still be totally removed.

3.5 If a laminating process is interrupted for a period causing the base laminate resin to exceed the point of gelation, a test is to be performed to verify adhesion between the base laminate and the top laminate. For each resin system, under the given processing conditions, the permissible period of interruption of the laminating process is to be determined. In the event of this period being exceeded, the laminate shall be thoroughly ground in order to provide a surface exhibiting adequate adhesion properties after removal of the dust. For UP resins on an orthophthalic acid and standard glycol basis not containing any skin-forming agents a 48 h interruption on the laminating process may, without any further proof being furnished, be considered uncritical with respect to lamination.

3.6 When grinding laminates containing resins with low styrene evaporation as the matrix system, the surface shall be removed down to the mat layer. In order to ensure that no skin-forming agent elements (e.g. paraffins) will be left on the surface, the surface shall finally be polished using new abrasive paper. The same procedure shall also be applied when treating the surfaces of materials to be bonded (see 6).

3.7 Transitions between different thicknesses of laminate shall be made gradually. A minimum value (for glass fabric in the fibre direction) of 25 mm per 600 g/m² reinforcing material can be used. In the transition region from a sandwich construction to a solid laminate, the core material shall be tapered with a gradient of not more than 1 : 3.

3.8 If cutting of reinforcing layers is unavoidable in the case of complicated mouldings, then the cut edges shall overlap, or reinforcement strips shall be provided. In the butt or seam region of laminates, every reinforcing layer shall overlap by at least 25 mm per 600 g/m².

3.9 Different components may be laminated together only while they are not fully cured. Special attention shall be paid to crossings of laminates.

3.10 Parallel or insert linings shall be free of all moisture and pollution (dirt). Their bonding surfaces with the laminate shall be prepared in a suitable manner (roughening, coupling agent or similar).

4. Glass-fibre resin spraying

Glass-fibre resin spraying, a partly mechanical method of lamination by hand, requires fulfillment of the following specific requirements:

4.1 The equipment to be used shall be demonstrated before use and its suitability proven.

4.2 The qualification of the fibre-resin sprayer, and where appropriate his assistant, shall be demonstrated to BKI by means of procedure test.

4.3 The equipment shall be calibrated in accordance with the guidelines of the manufacturer. Calibration shall be checked regularly before fibre-resin spraying, but the very least at the beginning of every production day.

4.4 The length of a roving cut shall be between 25 mm and 50 mm.

4.5 A powder-bound textile glass mat of maximum 450 g/m² shall be used for the first laminate layer. The glass part of this layer (to be applied manually) shall be less than 30 % by weight.

4.6 The glass weight per unit area of the spray laminate layer of a combined laminate shall not exceed 1150 g/m².

4.7 After a maximum of 1150 g/m² of fibres have been sprayed, air shall be removed and the composite shall be compacted.

4.8 Tests shall be performed on a regular basis to check whether a uniform laying up of the reinforced layers as well as a uniform distribution of percentage glass weight has been achieved. BKI reserves the right to demand test pieces to check the resulting mechanical properties.

5. Curing and tempering

5.1 Completed components may only be taken from the moulds after adequate curing of the thermosetting resin compounds. The required cure time generally depends on the manufacturer's instructions. Otherwise, a minimum cure time of 12 hours at 20°C shall be observed for cold-setting systems.

5.2 Resin systems which cure under pressure, UV radiation and/or increased temperature shall be treated in accordance with the manufacturer's instructions.

5.3 Immediately after curing, the components should receive post-treatment at increased temperature (tempering). The tempering time depends on the resin in question and the temperature attained within the component during tempering, whereby this shall be below the temperature for dimensional stability under heat and shall be agreed on with BKI. Cold-setting systems which are not subsequently tempered shall be stored for 30 days at a temperature of 16 °C, and for correspondingly shorter periods at temperatures up to 25 °C. This period can be shortened with the consent of BKI, provided the relevant manufacturer's specifications regarding post-curing are available, or post-curing values exist which are supported by experimental results. If such values are not available, then in general the following tempering conditions can be used (polyester/epoxy resin):

at least 16h at 40°C/50°C or

at least 9h at 50°C/60°C

6. Adhesive Bonding

6.1 Adhesive joints

6.1.1 Adhesive joints for load-bearing parts shall generally be verified by tests to be agreed on for each individual case, unless comparable experience is available.

Note

Particularly in the case of highly thixotropic adhesives, prior proof of their suitability shall be given with due consideration of the production process.

6.1.2 A specification for production and testing shall be compiled for the adhesive joints of loadbearing structures. In particular, the nominal values and tolerances of adhesive-layer thicknesses as well as the maximum size and extent of permissible flaws shall be defined. The adhesive layer thicknesses, tolerances and the maximum size and extent of permissible flaws shall be considered during the computational verification of the adhesive joint.

6.1.3 Only adhesives with confirmed properties may be used for bonding. The adhesives may not have any negative effects on the materials to be joined.

6.1.4 The possibility of contact corrosion (bondline corrosion) shall be countered by suitable means.

6.1.5 If FRP components are to be bonded and a resin system differing from the laminating system is used, the components shall be totally cured before bonding.

6.2 Assembly process

6.2.1 The various surface pre-treatments for synthetic materials and metals are for example compiled in VDI 2229 and VDI 3821.

6.2.2 The surfaces of the materials to be bonded together shall be dry and free of release agents (wax, grease, oil etc.), impurities (dust, rust etc.) and solvents. Especially when using solvents for cleaning purposes, compatibility with the material and sufficient ventilation time shall be ensured.

6.2.3 Smooth surfaces shall be roughened either mechanically (rough-grinding, sand-blasting etc.) or chemically by etching. It is absolutely necessary that layers on the surface of the materials to be bonded that exert a negative effect on the bonding process (e.g. skin-forming additives in polyester resins or residues of peel ply in the case of FRP, or oxide layers in the case of aluminium) be removed.

6.2.4 In many cases, an increase in the strength of the bonded connection can be achieved by the use of specially matched primers. The use of primers is particularly recommended for bonded joints which later in service are relatively heavily stressed by environmental influences.

6.2.5 The adhesive shall be processed in accordance with the manufacturer's instructions; the proportion of fillers may not exceed the permitted limit. When mixing the adhesive, its constituents shall be mixed in such a way that they are evenly distributed, care being taken to beat in as little air as possible.

6.2.6 The adhesive shall be applied evenly and as bubble-free as possible to the materials to be joined. If highly thixotropic adhesives are used, it is advisable to apply a thin undercoat of the corresponding pure resin to the surfaces to be joined.

6.2.7 Following application of the adhesive, the materials to be joined shall be brought together without delay and fixed in place.

6.2.8 A loading of the adhesive joint before the adhesive has cured sufficiently is inadmissible. For all adhesive joints with thermosetting adhesives, subsequent tempering of the joint is recommended; in the case of cold-curing adhesives, tempering is necessary as a rule.

6.2.9 After curing, the adhesive joint shall be protected by suitable means against penetration by extraneous media (e.g. moisture).

F. Manufacturing Surveillance

1. General

1.1 For components made of FRP, manufacturing surveillance consists of the quality control of the basic materials, production surveillance and the quality inspection of the finished components.

1.2 In the case of manufacturing surveillance, a distinction is made between internal and third-party (external) surveillance. In the sense of these Regulations, third-party surveillance means periodic and random checks by BKI of the internal surveillance as well as of the component quality.

1.3 BKI reserves the right to carry out inspections in the production facilities without giving prior notice. The manufacturer shall grant inspectors access to all areas used for production, storage and testing and shall present all documentation concerning records and tests carried out.

1.4 The scope of third-party surveillance can be reduced in the case of production facilities that have a certified quality management system.

2. Incoming inspection

2.1 The characteristic values and properties of material shall be verified by the manufacturer, by means of inspection documents. The following inspection documents according to EN 10204 (ISO 10474) are required as a minimum:

EN 10204-2.2 Fibre products, gelcoat resins, paints

EN 10204-2.3 Laminating resins, prepregs, core materials, adhesives

2.2 During the incoming inspection, the goods shall at least be checked for any damage and for compliance of the details in the certificates with the requirements. Material values shall be checked by random sampling.

2.3 The goods shall be stored in accordance with the requirements of the manufacturer and these Rules.

3. Production surveillance

3.1 Details of production process shall be laid down by specifications which also contain specimen documents for production and testing of the components. The tasks and responsibility of the production and quality control departments shall be defined clearly.

3.2 As the work progresses, the individual production steps shall be signed by the employees responsible for each stage on the basis of the prescribed documentation.

3.3 The individuals entrusted with production shall be trained in accordance with their task, and shall work under professionally qualified supervision. In the case of adhesive joints, the responsible supervisors shall have an appropriate qualification in adhesives, and the individuals performing the work shall have undergone suitable training.

Note

Training as adhesive bonding worker / adhesive bonding specialist according to DVS-EWF 3305 is desirable.

3.4 The batch numbers of the materials used in the component shall be given in the production documentation, in order that they can be traced back to the manufacturer if need be. Reinforcing layers introduced into the laminate shall be checked off immediately during the production process, with indication of the fibre direction.

3.5 From every batch of reaction resin compound, a sample shall be taken and tested. If mixing is performed continuously, one sample per batch and production step is sufficient. These samples shall be randomly checked for their degree of curing. The results shall be recorded.

3.6 On request by BKI, reference laminates of about 50 × 50 cm shall be produced in parallel. This shall result in confirmation of the material values used as a basis for the strength calculations.

4. Structural tests

4.1 During production and on completion of production, the component shall be subjected to visual inspections. In particular, attention shall be paid to voids, delamination, warping, discoloration, damage etc. In addition, the general quality, e. g. surface finish, shall be assessed.

4.2 By means of suitable testing procedures, the quality of the components shall be determined, if possible during production, and at the latest on completion of production. Special attention shall be paid to the bonding and to the degree of curing of the component.

4.3 Following agreement with BKI, individual or random tests shall be carried out on finished components under static and/or dynamic loads.

4.4 BKI shall be informed about repairs of any faults relevant to the strength of the component, and the procedure used to carry out the repair shall be in accordance with Section 3.

Section 2

Inspection and Testing of Fibre Composite Materials

A. Requirements

1. General

1.1 In accordance with the Rules and Guidelines of Biro Klasifikasi Indonesia (BKI), the materials used for manufacturing components made of FRP under the supervision of BKI shall be approved by BKI. Approvals are granted for the following materials:

- Gelcoat and/or laminating resins
- Reinforcing materials
- Prepregs
- Core materials
- Adhesives

1.2 Applications for approval by BKI Head Office shall be made by the material manufacturer or an agent. Together with the application, the following shall be submitted to BKI Head Office:

- Product description
- Safety data sheet
- Storage and processing instructions
- A declaration in writing by the applicant that the tested materials comply with those for which the approval is requested, and that the sample is manufactured in accordance with the Rules and Guidelines of Biro Klasifikasi Indonesia.
- Copy of the test certificate of a recognized testing body, i.e. an accredited testing laboratory or a notified testing body.

1.3 The tests shall be carried out in accordance with the standards mentioned in these Rules. However, comparable standards of other countries are also acceptable after agreement with BKI Head Office in each individual case.

1.4 The minimum properties required by BKI for the tests shall be fulfilled by all specimens.

1.5 In the case of inadequate test results of individual specimens, attention shall be paid to the following (for a basic number of 6 tests):

- If one or two specimens yield inadequate results, the tests shall be repeated with twice as many specimens.
- If the test results are inadequate for three or more specimens, the test can be repeated on newly produced specimens, provided that BKI agrees to this.
- If even one sample yields inadequate results while repeat-testing, then approval is not possible.

1.6 If the material fulfils the BKI requirements, then a statement of material approval is issued by BKI Head Office. This is generally valid for four years, whereby extensions are possible.

1.7 BKI Head Office shall be notified immediately of all modifications or other changes, to the material. Decisions regarding the further validity of the material approval is made on an individual basis.

1.8 A constant material quality shall be provided by the manufacturer through suitable QM measures. If this is not ensured, BKI reserves the right to suspend, or withdraw, the approval.

1.9 BKI reserves the right to demand and/or carry out spot tests of the material properties during the period required for material approval. If, in doing so, there is no adequate comparison with the required values, the material approval can be suspended or withdrawn by BKI.

1.10 The approval refers only to the approved material. The applicability of this material in connection with other approved materials shall be demonstrated independently by the manufacturer, or the user, in a suitable manner. In cases of doubt, BKI reserves the right to require a check of the properties of the material combination.

2. Thermosetting resins

2.1 General

2.1.1 The basic requirements listed under item 1apply for material approval.

2.1.2 A general description of the thermosetting resin, its processing conditions as well as the properties of resin in the processing state shall be submitted. The basic properties of the cured thermosetting resin shall be verified by the test certificate of a recognized testing body. These values shall fulfil specified minimum requirements.

2.1.3 Cold-setting unsaturated polyester (UP) resins and cold-setting epoxy (EP) resins are specifically described below. Other types of resins can also be approved after consultation with BKI Head Office, whereby the required minimum properties are specified by BKI Head Office on an individual basis. However, they shall at least comply with those of UP resins.

2.2 Description

2.2.1 A description of the thermosetting resin shall be submitted in order to allow an unequivocal identification:

– Resin type and state
– Purpose
– Manufacturer
– Trade name

2.2.2 In addition, the following shall be indicated:

– Storage conditions
– Environmental conditions for processing
– Type and proportion of allowed additives
– Curing conditions, tempering

2.3 Properties in the processing state and during curing

The properties shall be determined in accordance with the following standards:

– Density (ISO 1675)
– Viscosity (DIN 53015 ISO 2555)
– Reactivity:

  UP resins: acid number (ISO 2114)

  EP resins: epoxy equivalent (ISO 3001)

– WP resins: Monomer proportion (ISO 3251)
– Gel time (temperature increase) (DIN 16945, Section 6.2, 6.3 ISO 2535)
– Curing shrinkage (DIN 16945, Section 6.5)

2.4 Properties in the cured state

2.4.1 The following properties shall be submitted for all thermosetting resins in the cured state:

– Density
– Water absorption
– Strength, modulus of elasticity in tension, and tensile fracture strain
– Strength and modulus of elasticity in bending
– Dimensional stability under heat

2.4.2 For gelcoat and topcoat resins, the following additional information shall be submitted:

– Abrasion resistance (DIN 53754 -ISO 9352) 3 samples
– Resistance against seawater, fuels, hydraulic oil, weak acids and alkalis (ISO 175)

2.4.3 With regard to the properties, the following shall be verified by the test certificate of a recognized testing body. For this purpose, specimens shall be used which are produced in accordance with the submitted processing guidelines. The specimens shall be cured and tempered for 16 h at 40 °C (polyester resins) or 16 h at 50 °C (epoxy resins). For gelcoat and topcoat resins, only the first four properties shall be verified:

– Density (ISO 1183, method A), 3 specimens
– Water absorption (DIN EN ISO 175, Specimen 50 mm x 50 mm x 4mm), 3 specimens
– Dimensional stability under heat (ISO 75, method A), 3 specimens
– Tensile strength, fracture strain, modulus of elasticity in tension (ISO 527-2, test piece 1 B), 6 specimens
– Bending strength (ISO 178), 6 specimens
– Modulus of elasticity in bending (ISO 178), 3 specimens

2.4.4 The mechanical properties are normally determined at standard climate 23/50 (23°C / 50% relative humidity). If the intended operating temperature range of the resin is not between - 20°C and +50°C, further testing temperatures shall be agreed on with BKI Head Office.

2.4.5 The testing speed in the case of tensile and bending tests shall be selected in such a way that a specimen or edge-fibre strain of about 1 % / min is ensured. This shall be documented in the test report. The modulus of elasticity shall be determined as a secant modulus between 0.05 % and 0.25 % strain. The water absorption shall be specifically determined at 23 °C after 24 ± 1 h and 168 ± 2 h.

2.5 Minimum properties

2.5.1 For resin products consisting of UP resins, the following minimum properties are specified for use as laminating resins (values for gelcoat resins in brackets):

Tensile strength:	40 MPa	(—)
Fracture strain:	2.0 %	(3.0 %)
Modulus of elasticity (tension):	2700 MPa	(—)

Bending strength:	80 MPa	(—)
Dimensional stability under heat:	60 °C	(60 °C)

The water absorption after 168 h shall not exceed 70 mg for laminating resins and 60 mg for gelcoat resins.

2.5.2 The following minimum properties apply to resin products consisting of EP resins:

Tensile strength:	55 MPa	(—)
Fracture strain:	2.5 %	(3.5 %)
Modulus of elasticity (tension):	2700 Mpa	(—)
Bending strength:	100 Mpa	(—)
Dimensional stability under heat:	70 °C	(70 °C)

The water absorption after 168 h for laminating and gelcoat resins shall not exceed 50 mg.

2.5.3 The abrasion resistance properties and the resistance properties to extraneous media in the case of gelcoat resins may be determined by the applicant.

- The abrasion resistance determined in the test (sliding abrasion rate) shall be adequate.
- The properties stipulated in ISO 175 shall be determined after 24 h and 168 h at 23 °C. Taking these properties into account and following agreement between BKI Head Office and the applicant, the following classification is made:
  - Resistant,
  - Conditionally resistant
  - Not resistant

3. Reinforcing materials

3.1 General

3.1.1 The basic requirements listed under item 1 apply for material approval.

3.1.2 A general description of the reinforcing material and of the filament shall be provided. Basic properties of laminate specimens taken from the reinforcing material shall be verified by the test certificate of a recognized testing body. These values shall fulfil specified minimum requirements.

3.1.3 The following applies to fibre reinforcements made of glass and carbon. Products with other reinforcing fibres, e.g. aramide, can also be approved, following agreement with BKI Head Office, whereby the minimum properties are then specified on an individual basis.

3.1.4 Due to the great number of the fibre reinforcing products on the market, only the most common ones can be listed. Products not covered (e.g. complexes, hybrids), can also be approved, following agreement with BKI Head Office.

3.2 Description

3.2.1 A description is necessary which allows an unequivocal identification of the reinforcing material:

- Fibre material
- Reinforcement type (mat, fabric etc.)
- Manufacturer
- Trade name

3.2.2 In addition, the following is required:

– Form of supply

– Storage conditions

– Processing instructions

3.2.3 The filament and its treatment/sizing shall be submitted:

– Filament diameter (DIN 53811 - ISO R 137)

– Coupling agreed or sizing

– Resin compatibility

In the case of glass fibre products, the average filament diameter shall not exceed 19 µm.

3.2.4 In the case of reinforcing products consisting of a combination of different fibre materials and/or filaments, all fibre types shall be indicated.

3.2.5 If, in the case of textile glass reinforcing products, no E-glass or R-glass is used in accordance with DIN 1259-1, then an alkali oxide content (DIN ISO 719) of less than 1 % shall be verified by means of a test certificate from a recognized testing body.

3.3 Properties of the reinforcing products

3.3.1 Rovings

– Number of the filaments in the roving

– Roving fineness (ISO 4602)

When rovings are used as gun rovings (DIN 52316 -ISO 3375), the stiffness shall be additionally verified by the certificate of a recognized testing body.

3.3.2 Mats (continuous and chopped-strand mats)

– Fibre length (for chopped-strand mats)

– Linear density of the fibre (ISO 1889)

– Weight per unit area (ISO 3374)

– Layer thickness (ISO 3616)

– Binder (see 3.3.5)

3.3.3 Fabric

– Linear density of the fibres, warpwise and weftwise (ISO 1889)

– Count, warpwise and weftwise (DIN EN 1049-2)

– Weight per unit area (ISO 4605)

– Fabric thickness (ISO 4603)

– Weave (DIN 61101-T2)

3.3.4 Non-woven fabric

– Lay up

– Weight per unit area of the individual layers and of the non-woven fabric (ISO 4605)

– Non-woven fabric thickness (ISO 4603)

– Binder (see 3.3.5)

In addition if a non-woven fabric contains mat or fabric layers, then the linear density and, where appropriate, the fibre length shall be indicated.

3.3.5 A difference shall be made between chemical and mechanical bond types. In the case of chemical bond types, the binder, the percentage weight (glass ISO 1887, carbon DIN 29965) and its solubility (DIN 52332) shall be indicated. In the case of mechanical bond types, the type of weave shall be indicated.

3.3.6 In the case of reinforcing products with different fibre materials, the percentages of materials used in the respective reinforcing directions shall be indicated.

3.4 Laminate properties of the reinforcing products

3.4.1 For laminate production, it is strongly recommended that BKI-approved cold-setting UP resins are to be used. After curing, the specimens shall be tempered for 16 h at 40 °C. If, for special reasons, other (also warm-setting) thermosetting resins are to be used, then this shall be agreed in advance by BKI Head Office.

3.4.2 For rovings, tensile test specimens shall be prepared for all fibre materials in accordance with DIN 29965, Section 4.1.3.5. The test certificate of a recognized testing body shall be submitted to verify the tensile strength, the fracture strain and the modulus of elasticity as the mean values from six tests carried out in accordance with DIN 65382. Furthermore, the tensile strength and the modulus of elasticity shall be determined in accordance with DIN 65469 on flat specimens prepared for testing under tension.

3.4.3 For all other reinforcing products, laminate test panels shall be prepared in accordance with DIN EN 2374, Section 5.3 (Method C). In doing so, the reinforcing products shall be arranged in identical alignment. Depending on number of the reinforcing directions, the laminates should have approximately the following thicknesses: unidirectional laminates 2 mm, bi-directional laminates 4 mm and multi-directional laminates 5 mm.

3.4.4 Appropriate test panels shall be prepared by fibre resin spraying for the use of gun rovings. The length of the gun rovings in this case shall be 35 mm.

3.4.5 The gun prescribed number of specimens shall be cut out of the test panels for each test. In doing so, specimens shall be taken from each reinforcing direction of the laminate in order to test the mechanical properties. For products with randomly distributed reinforcing directions, specimens shall be taken from any two directions, but at right angles to each other.

3.4.6 The specimens shall be tested in accordance with DIN EN ISO 291 after at least 16 h under standard climate conditions.

3.4.7 The following properties shall be verified by the test certificate of a recognized testing body:

– Fibre content (glass ISO 1887, carbon DIN EN 2564), 3 specimens

– Tensile strength, fracture strain, modulus of elasticity in tension (ISO 527-4, test piece III), 6 specimens

– Bending strength, modulus of elasticity in bending (ISO 14125, Method A), 6 specimens

Deviating from the standard the modulus of elasticity in tension shall be determined as a secant modulus between 10 % and 50 % of the fracture strain.

In addition, for carbon fibres, the compressive strength and the modulus of elasticity in compression shall be demonstrated (carbon, Draft DIN EN 2850, test piece A1 with gauge length 8 mm).

3.4.8 The testing speeds shall be selected in such a way to ensure a strain rate of 1 % / min in the test piece or the edge fibre. The testing speed shall be indicated.

3.4.9 Testing shall be carried out in a standard climate 23/50 (23 °C / 50 % relative humidity). If the operating temperatures of the fibres are not between -20 °C and + 50 °C, then additional testing temperatures shall be agreed on with BKI Head Office.

3.5 Minimum properties

3.5.1 For approval, fibre reinforced products shall fulfil specified minimum values for the mechanical properties. The influence of the fibre volume content on the properties has been taken into account when specifying the values. The values refer to the 0° direction in the case of a uniform lay-up. If necessary, a correction to the actual lay-up should be done.

3.5.2 The minimum values of all mechanical properties to be verified are determined by means of the following equation together with the values given in Table 2.1:

$$X_{min} = \alpha \left[X_{ref} \left(\frac{\varphi}{0,4} \right) \right]$$

where:

X_{min} = minimum required value

X_{ref} = reference value for fibre volume content $\varphi = 0,4$

α = factor for lay-up

φ = fibre volume content $0,2 \leq \varphi \leq 0,6$

Deviations from the above specification are allowed for laminates with glass mats or gun rovings; in these cases, the minimum values for a percentage fibre weight content of $0,25 \leq \psi \leq 0,35$: are:

– Tensile strength:

$Rz = 1278\ \psi^2 - 510\ \psi + 123$ [MPa]

– Young's Modulus (tension]:

$E = [37\ \psi - 4,75] \times 10^3$ [MPa]

– Bending strength:

$R_B = 502\ \psi^2 + 106,8$ [MPa]

Table 2.1 Coefficients for the determination of the minimum properties

Fibre	Property	X_{ref} [MPa]	α			
			0°	0° / 90°	0° / ±45°	0° / 90° / ±45°
Glass	Tensile strength	500	1,00	0,55	0,50	0,45
	Young's Modulus of elasticity	26000	1,00	0,67	0,57	0,55
	Bending Strength	650	1,00	0,55	0,45	0,40
Carbon	Tensile strength	900	1,00	0,55	0,50	0,45
	Modulus of elasticity	80000	1,00	0,55	0,45	0,42
	Bending Strength	725	1,00	0,55	0,45	0,40
	Compressive strength	600	1,00	0,55	0,50	0,45
	Modulus of elasticity compression	70000	1,00	0,55	0,50	0,45

3.5.3 In the case of multidirectional lay-up of the reinforcing products, the values shall be proved at least for one direction (preferably 0°).

3.5.4 For reinforcing products with different fibre materials in one direction, the values of the material with the lower minimum properties shall be fulfilled.

3.5.5 The minimum values for fabric are 95 % of the specified values for 0°/90° lay-up.

3.5.6 The stiffness of the gun rovings to be verified in accordance with DIN 52316 shall not be below 130 mm.

3.5.7 The linear relationship between the property and fibre volume content assumed when specifying minimum values does not apply for all properties, and shall therefore not be used to extrapolate measured values.

4. Prepregs

4.1 General

4.1.1 The basic requirements listed under item 1 shall apply for material approval.

4.1.2 Since prepregs are based on resin systems which cure under heat, consultation with BKI Head Office concerning the curing process of the resins is required.

4.1.3 The testing of cured prepreg laminates is identical with the laminate testing of fibre reinforced products. Taking into account the resin system, the minimum characteristic values shall be agreed on with BKI Head Office.

4.1.4 Unidirectional non-woven prepregs and woven prepregs are considered within the framework of these Rules. Other prepregs can also be approved, following agreement with BKI Head Office.

4.2 Prepreg properties

4.2.1 A description is necessary which allows an unequivocal identification of the prepreg:

- Fibre material
- Resin system
- Reinforcement type
- Trade name
- Manufacturer
- Storage conditions, processing guidelines

4.2.2 The following properties shall be submitted for the non-cured prepreg material:

- Mass per unit area (DIN 53854)
- Resin percentage by weight (DIN 29971, Section 5.1.1.4)
- Layer thickness (DIN 53855-1)
- Resin fluxpercentage by weight (DIN 65090, Section 5.1.1)

4.2.3 The following are necessary for the reinforcing material:

- Filament diameter (DIN 53811 - ISO 137)
- Count (EN 1049-2)
- bond type (only woven prepregs)

5. Core materials

5.1 General

5.1.1 The basic requirements listed under item 1 shall apply for material approval.

5.1.2 A general description of the core material shall be submitted. The basic properties shall be verified by the test certificate of a recognized testing body.

5.1.3 Rigid foam materials and cross-grained balsa are considered specifically as a core material within the framework of these Rules. Cores made of other materials can also be approved, following agreement with BKI Head Office.

5.2 Rigid foams

5.2.1 The following information is necessary for a general description:

- Basic material and additives
- Trade name
- Manufacturer
- Resin systems suitable for bonding/coating
- Storage conditions

5.2.2 The manufacturer shall provide details of the maximum permissible processing temperatures and the operating temperature limits. The long-term operating temperature shall at least cover the range -20 °C to + 50°C.

5.2.3 The test certificate of a recognized testing body verifying the following properties shall be submitted:

- Apparent density (ISO 845); sample thickness ≥ 25 mm, 3 specimens
- Water absorption (ISO 2896), 3 specimens
- Compressive strength (ISO 844), 6 specimens, vertical to the plane of the test panel
- Modulus of elasticity (compression) (ISO 844) 3 specimens, test piece III, vertical to the plate plane of the panel
- Shear strength (DIN 53294), 6 specimens
- Shear modulus (DIN 53294), 6 specimens

5.2.4 The specimens shall be tested without foam skin. The testing shall take place in a standard climate 23/50 (23 °C/50 % relative humidity). Testing procedures are given mainly for rigid foams, whereas in the case of tough foams BKI Head Office shall be consulted if there is any doubt.

5.2.5 The following minimum properties are specified for an apparent density of 60 kg/m³ and 200 kg/m³:

	60 kg/m³	**200 kg/m³**
Compressive strength [MPa]	0,6	3,5
Modulus of elasticity (compression) [MPa]	40	200
Shear strength [MPa]	0,5	2,6
Shear modulus [MPa]	15	65
Water absorption [vol.-%] (after 28 Days)	2	2

5.2.6 In the case of other apparent densities, linear interpolation of the densities shall be used to determine strengths and moduli.

5.3 Cross-grained balsa wood

5.3.1 The requirements for cross-grained balsa wood are specified in Chapter 2 – Wood, Section 2.

5.3.2 Adhesion of balsa wood shall not be impaired by impregnation.

6. Adhesives

6.1 General

6.1.1 The basic requirements listed under item 1 shall apply for material approval.

6.1.2 A general description of the adhesive shall be provided. Basic properties of the cured adhesive shall be verified by the test certificate of a recognized testing body.

6.1.3 The following specifically considers cold- setting and hot-setting thermosetting adhesives as well as hot-melt adhesives. Other adhesives, provided that they can be used for processing of FRP (e.g. expansion adhesives) can also be used, following agreement with BKI Head Office.

6.2 Description

6.2.1 A description of the adhesive shall be submitted in order to allow an unequivocal identification of the adhesive:

- Type of adhesive
- Manufacturer
- Trade name
- Storage conditions
- Processing and curing guidelines
- Volume shrinkage after exceeding the gel point
- Glass transition temperature (ISO 11357/2)

6.2.2 In the case of adhesive films with backing, the backing material shall be specified.

6.3 Properties of the adhesive

6.3.1 In the processing state, the following information shall be provided:

- Density (DIN EN ISO 1675)
- Viscosity (DIN 53019)

6.3.2 In the case of two-component thermosetting resins which cure at room temperatures, the pot life (DIN 16945, Section 6.3) shall also be indicated.

6.4 Properties in the cured state

6.4.1 The following mechanical properties shall be verified by the certificate of a recognized testing body (on 6 specimens respectively):

- Tensile lap-shear strength (DIN EN 1465)

– Peeling resistance (DIN 53282)

– Dimensional stability under heat (ISO 75-2, Method A)

In addition, a long-duration shear tension test (based on EN 1465) shall be carried out. In doing so, the sample is subject to loads in a standard climate 23 °C / 50 % relative humidity at 60 % of the mean tensile lap-shear strength for 192 ± 2 h.

6.4.2 The testing shall be carried out for two different conditioning states of the specimens:

– 24 ± 1 h after curing at 23 °C and storage at 50 % relative humidity

– 1000 ± 12 h storage in distilled water at 23 °C

6.4.3 For each test and conditioning state, specimens with adhesive layer thicknesses of 0,5 mm and 3 mm shall be used.

6.4.4 All tests shall all be carried out in a standard climate 23 °C / 50 % relative humidity. In addition, the tensile lap-shear strength shall be verified at 50 °C.

6.5 Minimum properties

6.5.1 The following properties shall be achieved for directly tested specimens as well as specimens tested after wet storage:

– Tensile lap-shear strength: 12 MPa

– Peeling resistance: 2 N/mm

– Dimensional stability under heat 65°C

6.5.2 Strain in creep shall be below 0,18 mm in the long-duration shear tension test for an adhesive layer thickness of 0,5 mm and below 1 mm for an adhesive layer thickness of 3 mm.

This page intentionally left blank

Section 3

Repair of Components

A. General

1. Requirements for operation and personnel

1.1 Repairs shall only be performed by workshops which are approved by BKI for the repair of components made from fibre-reinforced thermosetting resins.

1.2 The shop approval for manufacturing components made of fibre-reinforced plastics using the hand lay-up method includes approval for repairing the parts within that production facility. For repairs out- side of the production facility (i.e. in the field), an extension of the shop approval is required.

1.3 The repairs shall only be carried out by persons with sufficient professional knowledge. This professional knowledge shall in general be verified by certificates of the corresponding training courses. If such certificates are not available, the minimum requirement shall consist of training completed for a technical profession, in conjunction with internal training and several months of experience.

1.4 The head of the repair team is responsible for proper execution of the repair and shall be named explicitly in the shop approval. His professional knowledge shall be verified by certificates of the corresponding training courses and professional experience of several years. In addition, a procedure test -to be carried out at the shop under supervision of BKI- is required.

1.5 The shop approval requirements shall be in accordance with Section 1, D.

2. Prerequisites

2.1 In the case of repairs which affect the structural integrity of the component, a repair plan shall be established and approved by BKI before the start at any repair work. If the same repair is to be carried out several times, a general repair plan can be established and submitted to BKI for approval.

2.2 Repairs to the gelcoat resin and (minor) repairs which do not fall under 2.1 shall be standardized and approved by BKI according to the standardized procedure.

2.3 For the approval of a repair according to 2.1, all design and repair drawings needed to assess the repair of the component shall be submitted to BKI. The repair plan will be examined by BKI Head Office and approved if found suitable.

2.4 A report is required for each repair and has to be signed by the head of the repair team.

2.5 Only materials approved by BKI shall be used for the repair.

2.6 The thermosetting resins used for repair shall be at least equivalent to the original thermosetting resin used for production. To ensure low residual stresses in the area to be repaired, the use of fast- setting highly reactive thermosetting resins shall be avoided. Unless the original thermosetting resin is used, the elongation at break of the thermosetting resins used for the repair shall be at least 2.5 %.

2.7 If the materials and laminates used for the repair are not identical to those employed when the component was manufactured, compatibility and equivalence of that particular combination of materials to the original ones shall be verified with respect to their properties.

B. Procedure

1. Preparation

1.1 Damaged material, or material which no longer exhibits complete bonding, shall be removed from the area to be repaired.

1.2 The region adjacent to the damaged area shall be chamfered. The chamfer ratio (chamfer length l_s to chamfer thickness t_s) depends on the tensile strength of the repair material, σ_{Mat}, in the chamfer direction, and the permissible shear stress τ. The minimum chamfer ratio shall be calculated by means of the following formula:

$$\frac{\sigma_{Mat}}{\tau} = \frac{l_s}{t_s} \cdot x$$

x = 1 for hand laminate

x = 1,05 in case of tempering

x = 1,15 for curing under vacuum and tempering

The permissible shear stress shall be 9 N/mm^2 for repairs in the shop and 7 N/mm^2 for repairs in the field.

1.3 The minimum overlap length for each layer shall not be less than 10 mm on all sides.

1.4 Because of the required draping ability needed (for curved surfaces and in the chamfered joint area; see Fig. 3.1), the weight per unit area of the reinforcing materials used for repair work shall, as far as possible, not exceed 600 g/m^2 per layer (more layers with less weight per unit area are better than only a few layers with a high weight per unit area).

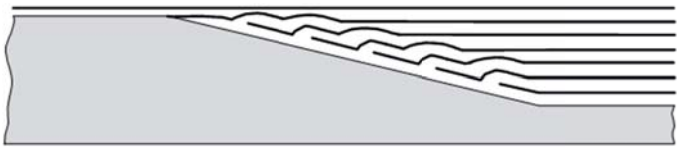


Fig. 3.1 Chamfered joint area for a repair (schematic)

1.5 In order that the stress magnification associated with a chamfered joint is as low as possible, at least three reinforcing layers should be used for each area to be repaired.

1.6 The area to be repaired shall be cleaned and grinded thoroughly, e.g. by using sandpaper with a grain of 80 or 120.

1.7 If the laminate has been in direct contact with water for a lengthy period, the laminate shall be dried properly before repair work is started.

1.8 As far as possible, the area to be repaired shall be relieved of the stress caused by its own weight. In the case of repairs performed in the field, special arrangements shall be taken if necessary to prevent the occurrence of external loads (e.g. caused by vibration).

1.9 For repairs in the field, the workplace shall be arranged in such a way that good accessibility to the area to be repaired and sufficient illumination are both ensured.

1.10 For repairs in the field, measures shall be taken against moisture as well as direct UV radiation.

1.11 The component temperature, at least within the repair area, shall be kept within the range permitted in 2.1.

1.12 The mixing ratio of resin to hardener shall be maintained as precisely as possible (in the case of epoxy resins, the relative deviation from the mixing ratio shall not exceed 3 %). The actual mixing ratio and the quantities used shall be recorded in a dosing report.

2. Execution

2.1 During the repair work and the curing period, a surrounding air and a component temperature between 16 and 25 °C as well as a maximum relative humidity of 70 % shall be maintained. If the resin or adhesive manufacturer has not specified other permissible values, these values shall apply.

2.2 Calibrated thermometers and hygrometers shall be used for monitoring in the vicinity of the repair or at a position agreed upon with BKI.

2.3 It shall be ensured that no changes in elongation occur in the laminate during the repair.

2.4 The lay-up at the prepared area to be repaired shall be performed by means of the hand lay-up method, as far as possible in the same sequence that was applied for the original laminate. The fibre orientation shall be identical.

2.5 Attention shall be paid to providing good impregnation of the reinforcing material. Voids shall be avoided.

2.6 A mat or fabric with a weight per unit area of approx. 225 g/m^2 (maximum 450 g/m^2 for boats) and a low percentage fibre weight content (approx. 30 %) shall be used as the final layer.

2.7 The laminate shall be given sufficient surface protection by means of a coating resin. If the repair areas are subjected to increased moisture levels, a high resistance to hydrolysis is required of the coating resin.

2.8 If unsaturated polyester or vinyl resins are used for the topcoat, inhibition problems shall be avoided by excluding atmospheric oxygen (e.g. by adding paraffin or using foil coverings).

3. Curing

3.1 During the curing process, it shall be ensured that no changes in elongation take place in the laminate.

3.2 Repaired components shall only be subjected to loads or put into further operation after the thermo-setting resin has cured sufficiently.

3.3 If no explicit values are quoted for the curing process by the manufacturer of the thermosetting resin system, the following time periods shall apply for cold-setting resin systems:

– For a constant temperature of 16 °C: at least 72 h,

– For a constant temperature of 25 °C: at least 38 h.

3.4 If the repaired component was tempered during manufacture, the area to be repaired shall also be tempered after setting, if no proof is provided to show that this is not necessary.

C. Documentation

1. Repair report

1.1 The repair report shall at least contain the following points:

– Designation of the component and, if applicable, its identification number

– Date and location of the repair (address of the shop or location in the field)

– Start time of repair

– Position and type of damage

– Repair plan and approval No.

– Climatic conditions during repair and the curing period (and the wind speed, in case the work was not performed within a closed room)

– Materials used (with batch number)

– Mixing ratios for thermosetting resin systems; dosing report

– Lay up (number of layers and orientation)

– Any deviations from the repair plan

– Duration of the repair

– Curing time

– Signature of the head of the repair team

Note:

To assist in describing and explaining the repair, sketches or pictures may be added to the repair report.

D. Enclosures

– Example of a survey report (F22.3.02)

– Example of a repair report (F22.3.03)

LAPORAN SURVEY PERBAIKAN KOMPONEN FRP

Survey Report for Repair of FRP-Components

No. :

Komponen (Pembuat) :
Component (Manufacturer)

Lokasi (WEC) :
Site (WEC)

No. Identifikasi Lainnya :
Other Identification No.

No. Reg. *Reg. No.*	Nama Kapal *Name of Ship*	Lokasi Perbaikan *Site of Repair*	Tgl. Perbaikan *Date of Repair*	Tgl. Survey *Survey Date*

Pemilik :
Owner

Pemeriksaan kelayakan/ kesesuaian bengkel kerja
Examination of suitability of workshop

- Persetujuan bengkel oleh BKI
  Shop approval by BKI ☐
- Nama kepala tim perbaikan :
  Name of head of the repair team
- Kepala tim perbaikan disebutkan namanya secara jelas dalam sertifikat persetujuan bengkel
  Head of repair team named explicitly in the shop approval ☐
- Tim perbaikan mengetahui tentang Peraturan Perbaikan Komponen
  Repair team familiar with Rules of Repair of Components ☐

Pengawasan Perbaikan
Repair Surveillance

- Rencana perbaikan telah disetujui oleh BKI
  Repair plan approved by BKI ☐
- Apakah persyaratan-persyaratan perbaikan komponen FRP telah dilaksanakan?
  Have the requirements for repair of FRP-components been followed ☐
- Penyimpangan dari Peraturan BKI atau dari rencana perbaikan (misalnya: material, kondisi iklim, pengerjaan)
  Deviation from BKI rules or from the repair plan (e.g. materials, climatic conditions, execution) ☐

  Uraian :
  Description

- Laporan perbaikan dilampirkan (F22.3.03)
  Repair report enclosed (F22.3.03) ☐

Tempat / *Place* , Tanggal / *Date*

Signature of BKI Surveyor

1 - ya/yes 2 - tidak/no

This page intentionally left blank

LAPORAN PERBAIKAN KOMPONEN FRP

Repair Report for FRP-Components

Data Komponen
Component Data

Penandaan :
Designation

No. Register (untuk Kapal):
Register No.

Lokasi (untuk WEC) :
Site (for WEC)

No. Identifikasi lainnya :
Other Identification No.

Pemilik :
Owner

Rincian Perbaikan
Details of Repair

Lokasi (perbaikan) :
Site (of the repair)

Tanggal :
Date

Kondisi cuaca pada saat perbaikan (setiap 3 jam)
Climatic conditions during repair (every 3 h)

Waktu *Time*	Temperatur *Temperature*	Kelembaban relatif *Relative Humadity*	Kecepatan Angin *Wind speed*
Mulai : *Begin*			
Selesai : *End*			

Material yang digunakan *Materials used*	No. batch *Batch number*	Pengakuan BKI *BKI Approval*	
Sistem resin *Resin system*		Ya ☐ *Yes*	Tidak ☐ *No*
Lapisan atas *Topcoat*		Ya ☐ *Yes*	Tidak ☐ *No*
Adhesif *Adhesive*		Ya ☐ *Yes*	Tidak ☐ *No*
Material penguat *Reinforcement material*		Ya ☐ *Yes*	Tidak ☐ *No*
		Ya ☐ *Yes*	Tidak ☐ *No*
		Ya ☐ *Yes*	Tidak ☐ *No*

Laporan Takaran *Dosing Report*				
No. Lot *Lot – No.*	Resin *Resin*	Bahan Pengering *Curing Agent*	Akselerator *Accelerator*	Waktu *Time*

Posisi dan tipe kerusakan (jika perlu sketsa atau gambar pada lembar/ halaman terpisah)
Position and type of damage (if necessary sketches or pictures on separate page(s))

Penjelasan deviasi dari rencana perbaikan (bila ada)
Description of deviations from the repair plan (if any)

Suhu maksimum dan minimum antara mulainya perbaikan dan penggunaan kembali komponen yang diperbaiki
Maximum and minimum temperature between start of the repair and commissioning of the repaired component

Maks : °C
Max.

Min : °C
Min.

Penggunaan kembali komponen yang diperbaiki
Comissioning of the repaired component

Tanggal :
Date

Waktu :
Time

,
Tempat / *Place* Tanggal / *Date*

Tanda Tangan Kepala Tim Perbaikan
Signature of the head of the repair team

RULES FOR THE CLASSIFICATION AND CONSTRUCTION

PART 1. SEAGOING SHIPS

VOLUME XIV
RULES FOR NON–METALLIC MATERIALS
2014 EDITION

CHAPTER 2 - WOOD

Biro Klasifikasi Indonesia
Jl. Yos Sudarso No. 38-40, Tanjung Priok
Jakarta 14320
www.bki.co.id
rules@bki.co.id

This page intentionally left blank

Table of Contents

CHAPTER 2 - WOOD

Section 1 - Requirements for Materials, Bonding Methods and Wood Protection ..... 1 / 22
A. General ..... 1 / 22
B. Types of Wood and Classifications ..... 1 / 22
C. Boatbuilding Plywood ..... 4 / 22
D. Plywood for Aircrafts ..... 13 / 22
E. Joining of Wood Materials ..... 21 / 22
F. Wood Protection ..... 22 / 22

Section 2 - Requirements for the Core Materials of Sandwich Laminates ..... 1 / 1
A. Cross-Cut Balsa Wood ..... 1 / 1

This page intentionally left blank

Section 1

Requirements for Materials, Bonding Methods and Wood Protection

A. General

1. Classification according to the field of application

1.1 Only proven boatbuilding wood shall be used for all timber components exposed to water and weather, i. e. timber with good resistance to water and weather, fungal attack and insect infestation, as well as with good mechanical properties that are also suitable for the particular application. Furthermore, it shall have a low swelling and shrinkage properties.

1.2 For components not exposed to water or weather, and not requiring strength, timber of lower durability may be used.

2. Quality

The timber used in boatbuilding shall be long-grained and of the best quality, i. e. be free from sap, shakes, objectionable knots and other defects. Twisted-grown or rough saw cut wood shall not be used.

3. Drying

3.1 The timber used shall be well seasoned and sufficiently dried, or shall be correctly dried in a suitable drying kiln.

3.2 For this purpose, the timber shall be stacked in piles which are as small as possible, so that uniform drying is guaranteed.

3.3 In the case of forced drying, the residual moisture content shall not be more than 10 %. When processing, this content shall not exceed a maximum of 15 % as a result of hygroscopic behaviour.

3.4 The moisture content shall be determined by establishing the loss of mass of a sample between its state at the time of draw-off and its state after drying, based on constant weight at 103 ± 2°C and the calculation of the weight loss as a percentage of the dry mass. This shall be done in accordance with DIN 52375 or ISO 9425.

B. Types of Wood and Classifications

1. Solid wood

1.1 Radially sawn timber shall mainly be used for boatbuilding. The angle of the annual rings to the lower sawn edge shall not be less than 45°.

1.2 Table 1.1 shows the number of different types of timber and their most important properties, such as durability, specific gravity, as well as bending, tensile and compressive strength. Since these properties can vary in the case of timber of the same type, or even within the same trunk, no absolute values are indicated in the table, but rather reference values. The timber listed is divided into durability groups from I to V, whereby:

I = very good

II = good

III = average

IV = moderate

V = poor

1.3 The timber used in boatbuilding shall, if exposed to the weather or used for the primary structural components of a boat, belong to at least durability group III.

1.4 In place of the timber listed in Table 1.1, other types can be used if the durability and the technological values are verified and are equivalent. The manufacturer shall always be responsible for the correct selection of the quality and type of wood.

1.5 Since wood has anisotropic material properties, these shall be taken into account during the design of the components. It shall be ensured that the main direction of stress lies in the direction of the greatest strength of wood, and that no impairment of function of the component is caused through the directional moisture coefficient of expansion.

1.6 The safety factors used in the strength calculations shall be agreed on in each case with BKI.

Table 1.1 Plywood strength groups

Timber type	Botanical name	Density, air-dried approx. [g/cm^3]	Durability	Mean tensile strength of plywood	
				Longitudinal [N/mm^2]	Transverse [N/mm^2]
Strength group : F1 (for load bearing components)					
Teak	Tectona grandis	0.64	I	40 ≤	30 ≤
Makore	Dumoria hekelii	0.62	I	40 ≤	30 ≤
Douka	Dumoria Africana	0.62	I	40 ≤	30 ≤
Utile	Entandrophragma utile	0.57	II	40 ≤	30 ≤
Sapele mahogany	Entandrophragma cylindricum	0.59	III	40 ≤	30 ≤
Oak	Quercus sp.	0.63	II	40 ≤	30 ≤
Strength group : F2 [1)]					
Bigleaf mahogany	Switenia macrophylla	0.49	II	$30 < \sigma < 40$	$20 < \sigma < 30$
Khaya mahogany	Khaya ivorensis	0.45	II – III	$30 < \sigma < 40$	$20 < \sigma < 30$
Okume (Gaboon)	Aucoumea klaineana	0.41	IV - V	$30 < \sigma < 40$	$20 < \sigma < 30$

1) Only for non-load bearing components

2. Plywood

2.1 General

2.1.1 Plywood consists of individual layers which are bonded together. In general, the layers can comprise veneers, wooden slats or small wooden slats. The panels described in these Rules as plywood shall consist exclusively of veneer layers.

2.1.2 The plywood panels consist of at least three veneers bonded transversely to each other (Table 1.2 or 1.3) by means of curable synthetic resin adhesives. The resistance of the adhesives to water and weather shall be demonstrated by long-term and outdoor testing. The number of veneer layers is dependent on the thickness and is defined C and D.

2.2 Grades

2.2.1 The plywood panels are divided into two grades KI I and KI II.

2.2.2 Both grades are identical with regard to required strengths, including resistance to adhesives. The only distinction is that the panels of grade KI I are suitable for use in one piece, whilst those of grade KI II may, because of non-permissible defects in the middle and outer layers, only be used separately after removal of the defects.

2.3 Panel dimensions

2.3.1 The dimensions of the plywood panels are to be specified by the customer, if standard dimensions in accordance with DIN EN 313-1 are not used.

2.3.2 The length of the panels is measured parallel to the grain of the outer layer, and is always specified first. The longitudinal and lateral tolerances are ± 5mm.

2.3.3 The permissible thickness deviation is:

up to 3 mm	± 10 %
over 3 mm	± 5 %, but maximum ± 0.5 mm

2.4 Bonding

2.4.1 The plywood panels shall be bonded without flaws (BFU 100 in accordance with DIN 68705). For this purpose, compliance with all decisive factors such as wood moisture content, pressing power, pressing temperature, pressing duration, glue characteristics, charging etc. shall be observed continually and carefully.

At present, the following synthetically-based adhesives are approved by BKI for plywood production:

- Phenolic adhesive (including phenolic adhesive film)
- Melamine resin adhesives
- Resorcinol resin adhesives

2.4.2 If a new glue is used, then faultless, error-free handling and bonding shall be demonstrated to BKI as well as absolute resistance to water and boiling.

2.5 Structure and requirements

Different requirements apply to the structures and plywood panels used in boatbuilding and aviation, as listed in C and D respectively.

2.6 Certificates

2.6.1 Biro Klasifikasi Indonesia issues certificates for tested and approved plywood panels, and these are handed over to the manufacturer and/or customer.

2.6.2 The certificate specifies, among other things, the plywood type, the number of plywood panels inspected, the stamping and, if requested, the average values of the test results.

2.6.3 Independent of the testing by Biro Klasifikasi Indonesia, the manufacturer is obliged to continually carry out his own shop-based quality control during all working steps, the selection of the wood and its processing during production of the plywood panels.

2.7 Storage of the plywood panels

2.7.1 Finished plywood panels which are placed in storage shall be kept in closed rooms and stored horizontally.

2.7.2 The plywood panels shall only be placed in horizontal stores that are at least 30 cm above the ground and from the walls, in order to avoid the effects of moisture.

2.7.3 The individual piles shall be protected against moisture from one side by covering panels.

2.7.4 Non-compliance with these storage requirements can lead to previous tests being declared invalid.

2.8 Strength calculations

The safety factors used in the strength calculations shall be agreed on, in each case, with BKI.

C. Boatbuilding Plywood

1. General

1.1 All plywood components exposed to water and weather, or used in primary structural components (such as the deck, shell and bulkheads), shall be produced from boatbuilding plywood that has been tested and in compliance with 10.6.

1.2 Boatbuilding plywood consists of at least three veneers bonded crosswise together (Table 1.2) by means of curable synthetic-resin adhesives. The resistance of these adhesives to water and weather shall be demonstrated by long-term and outdoor testing.

1.3 As plywood can also be destroyed in suitable conditions by animal or plant pests, timber shall be used which offers a natural resistance.

1.4 Independent of the testing by Biro Klasifikasi Indonesia, the manufacturer is obliged to continually carry out his own shop-based quality control of all working steps, the selection of the wood and its processing during production of the plywood panels.

1.5 The points listed under B.2 shall be taken into account.

2. Structure

2.1 The selection of timber and the structure of the panels (number of veneer layers) shall be appropriate for the field of application. Depending on the application, strong, durable timber - e.g. makore and the hard, durable mahogany types of strength group F1 (Table 1.1) - with several thin inner layers of veneer shall be selected for load-carrying components subject to high stresses. On the other hand, plywood panels of lighter, less strong and less durable timber of strength group F2 - e.g. khaya mahogany, okume - with thicker and fewer inner layers of veneer and good surface protection are suitable for linings.

2.2 In general, veneers of 1.5 mm thickness are used for the outer layers. However, efforts should be made to use thicker outer layers because of the later reworking necessary in boatbuilding. However, their thickness shall not exceed 2.6 mm because of increased danger of shakes in the veneers. In the case of inner layers, veneer layers in plywood panels up to 15 mm thick may not have a thickness in excess of 2.6 mm because of potential defects. For plywood panels thicker than 15 mm, veneer layers thicker than 3.8 mm may not be used.

2.3 Only in special cases and with the explicit permission by Biro Klasifikasi Indonesia this restriction can be waived. Such plywood panels are then assigned to the strength group F2 and marked accordingly in the BKI stamp.

2.4 The following table gives a list of the required minimum number and thickness of the veneer layers:

Table 1.2 Minimum number and thickness of the veneer layers

Plywood thickness [mm]	Minimum number of veneer layers	Minimum thickness of the outer layers	Greatest thickness of the inner layers
$t \leq 6$	3	1.5 mm	2.6 mm
$6 < t \leq 10$	5		
$10 < t \leq 15$	7		
$15 < t \leq 20$	7	1.5 mm	3.8 mm
$20 < t \leq 26$	9		
$26 < t \leq 34$	11		
$34 < t \leq 40$	13		
$40 < t \leq 48$	15		
$48 < t \leq 55$	17		

2.5 The veneer layers shall be symmetrical around the middle layer, both with respect to the grain as well as to the thickness of the layers.

2.6 The strength of the plywood panel can be increased, or its property adapted to specific requirements, through an increased number of veneer layers, addition of extra glue and increased pressing power, as well as through insertion of fabric layers.

2.7 For the production of boatbuilding plywood panels, only wood which is of the best quality, flawless, healthy, free from sap and spring wood shall be used for the outer and inner layers.

3. Veneer joints

3.1 The joints shall be sealed perfectly and shall bond the veneers to each other by butt joints. The joints shall be glued on a suitable joint bonding machine.

3.2 The strips of veneer of the outer layers shall be put together so that they match with regard to timber and colour.

3.3 Sealed joints between all layers are a precondition for boatbuilding plywood panels.

3.4 Paper or plastic adhesive strips may not be used to secure or repair inner veneer layers.

3.5 The joints of the different veneer layers shall be staggered.

3.6 Metal clamps used for securing purposes may only be positioned on the edges of the panels. They shall on no account remain on the panels when they are cut to standard dimensions.

4. Strength groups

4.1 With regard to their suitability for the production of boatbuilding plywood, the types of timber listed in Table 1.1 are currently approved. The timber is subdivided into two strength groups. Also shown is the natural durability and weathering resistance of the mentioned types of timber.

4.2 The plywood panels may be manufactured from one or several of the approved kinds of timber. If panels comprise different types of timber of both strength groups, then all panels are assigned to the group with the lower strength.

4.3 All boatbuilding plywood panels which are manufactured according to special specifications and conditions of the customer, or deviate from BKI requirements, are assigned to the appropriate group and stamped according to the plywood type.

4.4 Other types of wood may only be used for making plywood panels upon agreement with BKI. The manufacturer shall always remain responsible for the correct selection of the quality and type of wood.

5. Plywood grades

5.1 Boatbuilding plywood of the two strength groups is subdivided into two grades after inspecting its external and internal quality. In relation to their respective groups, grades I and II are identical with regard to type of wood, strength, production and bonding. They differ insofar that the panels of grade I can be used completely, while the panels of grade II are restricted to partial use because of local manufacturing defects or timber flaws.

5.2 The defects of grade II shall be limited to one third of the area of the panel. Two thirds of the panel shall be free of defects and suitable for use. The defects are identified during inspection by marking.

5.3 The visible side of the plywood panel shall be manufactured virtually without any defects and, furthermore, the quality, colour and grain shall be combined in such a manner that they match. The hidden surface may have small colour differences or slight blemishes which do not influence the strength of the panel.

6. Defects

6.1 The following wood and production defects are not permissible in the outer and inner veneer layers:

- Any bonding defects
- Loose contra-shaving wood; strongly curly-grained, short-fibred wood growth at right angles to the run of the grain; cross-cut timber
- Larger, more prominent wood discolouration or mould stains which tend to cause rot and all other defects which could have a noticeable affect on the strength of the panel
- Wood discolouration on both sides, or strong glue bleeding on both sides
- Loose black (dead) knots, holes, loose joints or blocking cracks in the veneer layers
- Overlapping of the veneer layers (folding).

The following can be permitted:

- Up to three healthy tight knots of 15 mm Ø maximum for each side of the panel
- Up to three knots of 25 mm Ø maximum on each side of the panel which have been perfectly repaired
- Up to three cracks of the veneer edge which have been perfectly repaired. The cracks may be up to 1/10 of the panel length and on each side of the panel.
- Small local edge flaws up to 3 cm length do not have to be considered.

Only one of the 4 types of permissible defects shall be present.

7. Repairs

7.1 Repairs may be carried out on the finished, pressed boatbuilding plywood panels to a limited extent, provided that the quality of the panel is not impaired in any way. The repairs shall be carried out at the appropriate temperature under pressing power with a glue which is resistant to water and weather.

7.2 Shakes of up to 1/10 of the panel length and 1 mm width, and small knot holes up to 5 mm Ø, may be repaired with wood putty of the same colour.

7.3 Wider shakes and defects of up to 1/10 of the panel length shall be bonded so that they are weather-resistant. In doing so, care shall be taken when fitting and selecting the strips such that they are from appropriate timber and have the same colour. The repair work shall be carried out under pressure in accordance with DIN 68705 BFU 100.

8. Surface treatment

8.1 After pressing, the plywood panels shall be subjected to sufficient soaking to ensure that their moisture content again rises to 6 – 12 %. The plywood panels may either remain unsanded or be lightly sanded.

8.2 The outer layers of the plywood panels cut to their final dimensions shall be at least 1.0 mm (after the pressing and sanding) at the thinnest point. When sanding the panels, special care shall be taken to ensure that this requirement is met.

9. Panel dimensions

9.1 The dimensions of the plywood panels are specified by the customer if standard dimensions are not used (see B.2.3).

10. Testing

10.1 General

10.1.1 In general, the finished boatbuilding plywood panels are tested and approved at the manufacturing shop by surveyor of Biro Klasifikasi Indonesia.

10.1.2 The inspection of finished plywood panels outside of the manufacturing shop is carried out by BKI only by way of exception and under stricter test conditions.

10.1.3 BKI reserves the right to also monitor the production of the plywood panels in the manufacturing shop.

10.2 Inspection of the plywood panels

10.2.1 The condition of all boatbuilding plywood panels is inspected and tested by BKI surveyors after their completion. In particular, attention is paid to bonding. The panels are allocated to the appropriate plywood strength group and grade, depending on the type of plywood and the quality and stamped.

10.2.2 The plywood panels submitted to BKI for inspection shall be examined, pre-graded, finished and then divided into test batches or orders by the manufacturer prior to inspection by the BKI surveyor. Panels with faulty gluing are examined more closely to determine whether the faults are locally or present over the whole panel. If the latter is true, the entire test batch is tested with special care. If there are several such panels in a test batch, then the entire batch is rejected. If leaky joints or blocking cracks are found at the plywood edges of the inner layers, then these defects shall not be plugged before the BKI inspection. The BKI surveyor will decide whether these defects can be corrected, or whether the panel shall be rejected or assigned to grade II.

10.3 Grading of the plywood panels

10.3.1 Grading of the panels shall be in accordance with the differences between grades I and II stipulated in 5. The panels are marked with the appropriate grade stamp.

10.4 Sampling

10.4.1 For the inspection of boatbuilding plywood panels, sample panels are taken from test batch intended for inspection and provided with a sample number.

10.4.2 Test pieces of approx. 25 cm length and 100 cm width are removed from these sample panels and provided with the sample number of the test panel.

10.4.3 The required samples are prepared from these sample pieces, and again provided with the sample numbers of the test panel.

10.4.4 If only a few panels of a particular plywood type, or very thick and large panels, are submitted for inspection, and if the effort involved in cutting these panels appears to be too great, then samples can also be taken from pieces cut off the edge of these panels. For this purpose, it is necessary, when trimming these panels, to put the edge cuttings aside.

10.4.5 The number of test panels is determined according to the following factors:

10.4.5.1 If continuous inspections by BKI in the manufacturing shop show that the production of the boat-building plywood panels appears to be reliable, and if the production is monitored continuously by suitable, automatic facilities or supervision, then it is not necessary to take test panels from each test batch.

10.4.5.2 It is sufficient to select approximately 2 % (by number) of the panels from the current production to be used as samples.

10.4.5.3 It shall be ensured that the test panels cover all plywood thicknesses and types.

10.4.5.4 If production problems occur, or if the BKI surveyor has the impression that the production is not always reliable, then the surveyor can insist on the selection a greater number of test panels.

10.4.5.5 If one or several test panels should exhibit inadequate values during the inspection, then an additional two panels from the same test batch shall be tested. If, once again, the minimum requirements are not satisfied during this inspection, then the complete test batch shall be rejected.

10.5 Sample type and quantity

From every test panel (or test strip) to be tested, the following samples shall be taken and prepared:

10.5.1 Two samples for the delamination test in order to determine, in accordance with DIN 53255, the bonding strength of the glue.

10.5.2 Eight samples in accordance with DIN 53255 for the adhesive tensile lap-shear test to check the delamination test. Simple tensile lap-shear samples shall be used in accordance with Fig. 1.1.

10.5.3 Six samples for the longitudinal strength test and six samples for the transverse strength test to determine the plywood tensile strengths in accordance with DIN 52377.

10.5.4 Two kiln-dried samples for the determination of the moisture content of the plywood and the specific weight (apparent density) in accordance with ISO 3130.

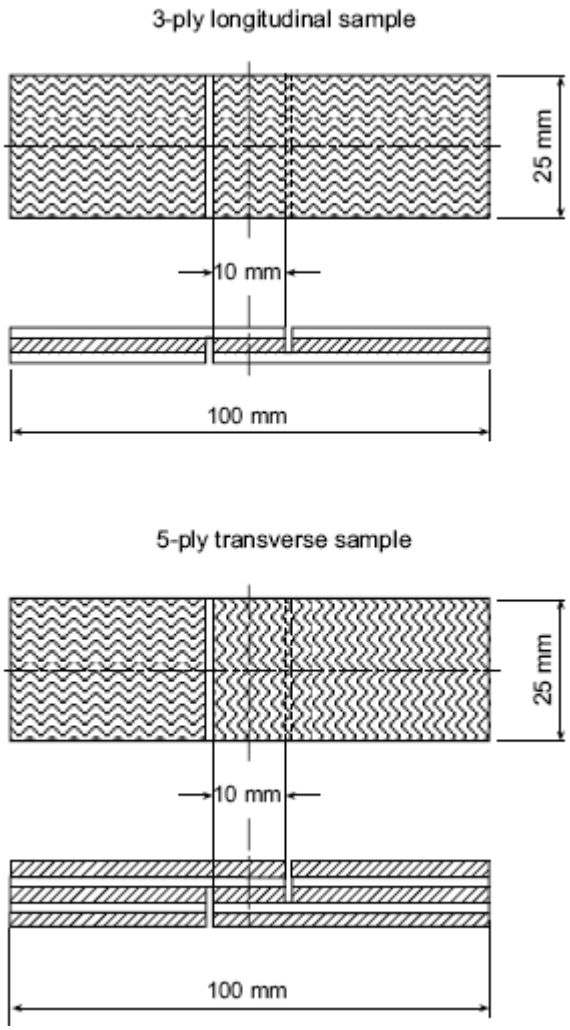


Fig. 1.1 Typical representation of a 3-ply longitudinal and a 5-ply transverse tensile lap-shear sample

10.6 Pre-treatment and testing of the samples

10.6.1 Glue bonding strength samples

10.6.1.1 Two delamination samples and eight tensile lap-shear samples are used for testing the bonding strength of the glue.

10.6.1.2 Before testing, these samples shall be subject to a boiling/drying alternation test and a short-time test BFU 100 in accordance with DIN 68705 and shall satisfy the test conditions of 10.6.1.3.

10.6.1.3 Storage of the samples in boiling water with intermediate drying at 60 °C in the following cycle:

4 hours boiling

16 hours drying

4 hours boiling

2 hours cooling under water at 20°C

10.6.1.4 The two delamination samples shall be subjected to a delamination test after this pre-treatment. The bonding shall offer considerable resistance to the forceful delamination of the veneers by means of a delamination tool, and the fracture area shall exhibit wood fracture and flawless bonding (see fracture diagrams DIN 53255).

10.6.1.5 The eight tensile lap-shear samples shall be tested in a wet condition in the testing machine and shall satisfy the following minimum values:

For timber of the strength group F1: at least 1.5 N/mm^2

For timber of the strength group F2: at least 1.2 N/mm^2

10.6.2 Plywood strength test

10.6.2.1 The six longitudinal tensile-strength samples and the six transverse tensile-strength samples shall undergo acclimatization prior to testing in the testing equipment and their moisture content shall be adjusted to 12 – 15 %.

10.6.2.2 From each of the six samples, three longitudinal and three transverse samples shall be tested in the testing machine and the average strength value determined for these three samples.

10.6.2.3 The two batches of three remaining samples serve as replacement samples for those samples which exhibit fractures at the clamping device with insufficient values. The fractured samples are then not to be used for evaluation purposes.

10.6.2.4 The samples shall have the minimum plywood strengths as specified in Table 1.1.

10.6.2.5 Plywood made from other types of timber shall be included in the strength group with which its properties comply.

10.6.2.6 If the production and the plywood strength at a manufacturing shop is continually monitored by BKI and if the determination of the plywood strength of individual test batches is considered to be irrelevant, then the inspection and determination of the plywood strengths of these test batches can be waived.

10.6.2.7 If plywood panels of the timber and strength group F1 do not achieve the required minimum plywood strength values of this group, then these panels can be assigned to the plywood strength group F2 and stamped accordingly.

10.6.2.8 All boatbuilding plywood panels which are manufactured according to special specifications and conditions of the customers, or which deviate from BKI Rules, are stamped according to their plywood type and strength group. The deviations or special features of such plywood panels shall be recorded in the test certificate.

10.6.3 Moisture test

10.6.3.1 The two kiln-dried samples are used for determining the moisture content of plywood. They shall be examined in accordance with ISO 3130. The moisture content of the plywood should be 5–12 % ex works.

10.6.3.2 Measurements of the moisture content of plywood by means of electrical measuring instruments can only be approved if check measurements using the kiln-dried samples have shown approximately identical values.

10.6.4 Determination of specific weight

10.6.4.1 For the determination of the specific weight of the plywood panels, the two kiln-dried samples shall be measured and weighed as precisely as possible in dry-air conditions before the kiln-drying.

10.6.5 Inspection of the plywood scarf jointing

10.6.5.1 The plywood scarf jointing shall be carried out in accordance with the conditions specified in E.2. and bonded with glues approved by BKI (B.2.) under pressing power and pressing temperature without

any flaws. The bonding of the scarf joint shall be checked by bending the panels over a test frame or a roller. If the scarf joints appear to be of doubtful quality, then this bending test shall be performed for both sides of the panels.

10.6.6 Additional tests

10.6.6.1 If for any reason the BKI surveyor has any doubts regarding the production and in particular the bonding of the plywood panels and its scarf jointing, then he shall be entitled to subject the test batch to additional tests of his choice, e. g. prising-open tests, knocking-off tests, bending tests, warping tests, soaking tests etc.

11. Marking and stamping

11.1 All boatbuilding plywood panels inspected by BKI surveyors and found to be in order shall be provided with the following stamping to identify the plywood type, grade and production:

- Stamping by the manufacturer:
  - Sign or mark of the manufacturing shop
  - Size and thickness of the panel.

    The plywood thickness is given in mm, the length and width of the panel in cm. The first dimension indicates the length of the panel in the longitudinal fibre direction of the outer layers.
  - Timber used for the outer and inner layers (separated by a dash).
  - Bonding type: "BFU 100"

  The panels may be stamped neutrally, i. e. without the manufacturer's details, if explicitly so required by the customer.

- Stamping by Biro Klasifikasi Indonesia:
  - A rectangular BKI stamp, with the following details:
    - Boatbuilding plywood
    - Plywood grade I (or II)
    - Biro Klasifikasi Indonesia
    - Testing date
  - A BKI roller stamp along the end of panel with the identifying grade I or II and the testing date. The strength group F1 or F2 is applied by the same roller stamp, but with the addition "F1" or "F2" below the date.

As a rule, the stamping should be applied on the bottom right of that side of the panel which is of lesser quality (i. e. on the back).

11.2 In the case of long scarf-jointed panels, the BKI stamp shall be made on both ends of the panel.

11.3 Since inspection is only carried out randomly, the inspector is entitled to reject panels which have already been stamped, if they should prove to be defective.

11.4 The stamps have the following appearance, for example:

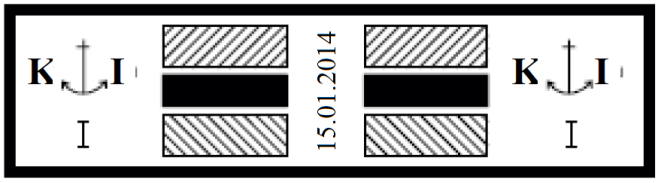
Manufacturer stamp:

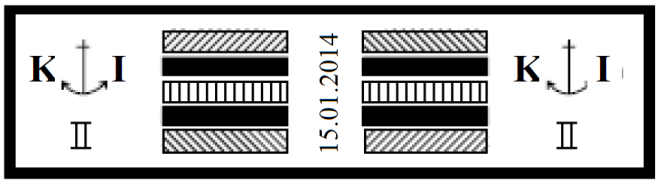
Mark of the shop
250 x 122 x 6
Macore - Macore
Rotary veneer Rotary veneer
BFU 100

BKI stamp:

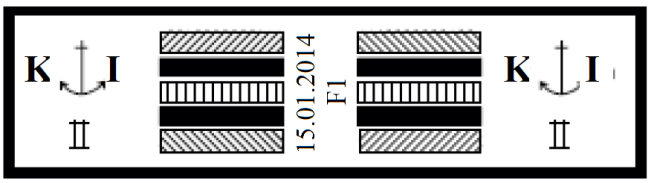
Boatbuilding plywood
Grade I (or II)
Biro Klasifikasi Indonesia
15.01.2014

Roller stamp to identify the grad:





Roller stamp to identify the strength group:



12. Certificates

12.1 Biro Klasifikasi Indonesia issues certificates for boatbuilding plywood panels which have been tested and approved, and these certificates are given to the manufacturer or customer.

12.2 The certificate shows, among other things, the plywood types, the number of plywood panels inspected, the stamp and, if requested, the average values of the test results.

13. Storage of the plywood panels

13.1 Finished plywood panels which are placed in storage shall be kept in closed rooms and stored horizontally.

13.2 The plywood panels shall only be placed in horizontal stores that are at least 30 cm above the ground and from the walls, in order to avoid the effects of moisture.

13.3 The individual stacks shall be protected against moisture from one side by covering panels.

13.4 Non-compliance with these storage requirements can lead to previous tests being declared invalid.

D. Plywood for Aircrafts

1. General

1.1 The plywood consists of at least three transversely veneer layers (Table 1.3). The bonding is with curable synthetic resin adhesives. The resistance of the adhesives to water and weather shall be demonstrated by long-term and outdoor testing.

1.2 Independent of the testing by Biro Klasifikasi Indonesia, the manufacturer is obliged to continually carry out his own shop-based quality control of all working steps, the selection of the wood and its processing during production of the plywood panels.

1.3 The points listed under B.2 shall be taken into account.

2. Structure

2.1 The selection of the timber and the structure of the panels (number of veneer layers) shall be appropriate for the field of application.

2.2 The veneer layers shall be symmetrical around the middle layer, both with respect to the grain as well as to the thickness of the layers.

2.3 The thicknesses shall be selected in such a way that, as far as possible, the same strength is ensured in the longitudinal and lateral direction. BKI reserves the right to exclude any panels with an unsuitable structure from the testing.

2.4 The following table gives a list of the required minimum number and thickness of the veneer layers:

Table 1.3 Minimum number and thickness of the veneer layers

Plywood thickness [mm]	Minimum number of veneer layers	Remarks
$t \leq 2$	3	No layer shall be thicker than 2 mm
$2 < t \leq 6$	5	
$6 < t \leq 14$	7	
$14 \leq t$	≥ 9	

2.5 Birch, beech, alder, okume (gaboon) or other timber may be used, provided that the properties of the respective timber strength group are ensured.

2.6 Only binding agents (adhesives) authorized by BKI may be used (see B.2).

2.7 Surface treatment

2.7.1 The panels may be manufactured as unsanded, lightly sanded, scoured, smoothed, resined or unresined.

2.7.2 The outer layers shall still be thick enough after processing so that reliable subsequent processing is ensured.

3. Veneer joints

3.1 Unless otherwise agreed between contractor and manufacturer, panels bonded with synthetic-resin adhesive may have veneer joints parallel to fibre direction in the middle and outer layers.

3.2 The joints shall be sealed perfectly and shall bond the veneers to each other by butt joints. The joints shall be glued on a suitable joint bonding machine.

3.3 The joints of the various veneer layers shall be staggered.

3.4 The strips of veneer of the outer layers shall be put together so that they match with regard to timber and colour.

3.5 Paper or plastic adhesive strips may not be used to secure or repair inner veneers layer.

3.6 Metal clamps used for securing purposes may only be positioned on the edges of the panels. They shall on no account remain on the panels when they are cut to standard dimensions.

4. Strength groups

4.1 With regard to their suitability for the production of aviation plywood, the timbers listed below are currently approved; these have been divided into two strength groups.

Table 1.4 Strength groups

Timber	Strength group	Mean tensile strength of plywood MPa		
		Long.	Transv.	Long. + Transv. (added)
Birch	F1	≥ 70	≥ 45	≥ 140
Beech		≥ 70	≥ 45	≥ 140
Alder		≥ 70	≥ 45	≥ 140
Okume (Gaboon)	F2	≥ 45	≥ 30	≥ 90
Poplar		≥ 45	≥ 30	≥ 90

4.2 In the case of panels over 3 mm thick, these values may be reduced by a maximum of 10 %.

4.3 Other types of wood may only be used for making plywood panels upon agreement with BKI. The manufacturer shall always remain responsible for the correct selection of the quality and type of wood.

5. Plywood grades

5.1 Plywood of the two strength groups is subdivided into two grades after inspecting its external and internal quality. In relation to their respective groups, grades I and II are identical with regard to type of wood, strength, production and bonding. They differ insofar that the panels of grade I can be used completely, while the panels of grade II are restricted to partial use because of local manufacturing defects or timber flaws.

5.2 The defects of grade II shall be limited to one third of the panel area. Two thirds of the panel shall be free of defects and suitable for use. The defects are identified during inspection by marking.

5.3 The visible side of the plywood panel shall be manufactured virtually without any defects and, furthermore, the quality, colour and grain shall be combined in such a manner that they match. The hidden-surface may have small colour differences or slight blemishes which do not influence the strength of the panel.

6. Defects

6.1 The following wood and production defects are not permissible in the outer and inner veneer layers:

- Loose, mouldering knots, rotten knots, holes in the middle layers
- Firm knots over 6 mm diameter
- In the case of three-ply panels, more than four knots in one layer of a 100 x 100 cm large panel
- A distance of less than 200 mm between the knots.
- In the case of five- or multi- ply panels, more than six knots in one layer and less than 150 mm distance between the knots.

  If the panel sizes are different to those specified above, the number of the permissible knots changes in accordance with the area. Knots up to 30 mm from the edge do not have to be taken into consideration.
- Short-grained, curly-grained and cross-grained wood, variegated appearance and discolouration, and mould stains if they decrease the strength and bending capability significantly.

  Small signs of mould stains as well as bark specks do not have to be taken into consideration.

  Short-grained or curly-grained wood covers such wood whose grain is interrupted and which has different growth directions (see photo, DIN 68256).
- Knot and shake scars and intergrown knots (see photo, DIN 68256).

Furthermore, the following manufacturing errors are not allowed:

- Joints which transgress the defined type, and inserted pieces (shims)
- Unbonded, open and badly closed joints
- Folds and shakes, breaks, peeling defects and bubbles as well as other such defects which decrease the strength of the panel. Up to three instances of damage, folds or shakes less than 30 mm from the edge of the panel do not have to be taken into consideration if they are not on opposite sides of the panel.
- Corrugated or bent panels
- Areas without binding agent, e.g. damage to the film of glue, insofar as these areas were not covered
- Heavy glue bleeding on more than one side of a panel.

7. Testing

7.1 General

7.1.1 In general, the finished plywood panels are tested and approved at the manufacturing shop by an surveyor of Biro Klasifikasi Indonesia.

7.1.2 The inspection of finished plywood panels outside of the manufacturing shop is carried out by BKI only by way of exception and under stricter testing conditions.

7.1.3 BKI reserves the right to also monitor the production of the plywood panels in the manufacturing shop.

7.2 Inspection of the plywood panels

7.2.1 With respect to structure, and in particular bonding, all plywood panels are examined by BKI and carefully tested after their completion by a BKI surveyor. The panels are assigned, depending on the

plywood type and quality, to the appropriate plywood strength group and grade. They are then graded and provided with the appropriate group and grade stamp.

7.2.2 The plywood panels submitted to BKI for inspection shall be examined, pre-graded, finished and then divided into test batches or orders by the manufacturer prior to BKI inspection. Panels with faulty gluing are examined more closely to determine whether they are only limited locally or are present over the whole panel. If the latter is true, the entire test batch is tested with special care. If there are several such panels in a test batch, then the entire batch is rejected. If leaky joints or blocking cracks are found at the plywood edges of the inner layers, then these defects shall not be plugged before the BKI inspection and decision of the BKI surveyor as to whether these defects can be corrected, or whether the panel shall be rejected or assigned to grade II.

7.3 Grading of the plywood panels

7.3.1 Grading the panels shall be in accordance with the differences between grades I and II specified in 5. The panels are marked with the appropriate grade stamp.

7.4 Sampling

7.4.1 For the inspection of the plywood panels, test panels are taken from the test batch submitted for inspection and provided with a sample number.

7.4.2 Test pieces of approx. 25 cm length and 100 cm width are removed from these sample panels and provided with the sample number of the test panel.

7.4.3 From these test pieces, the required samples are prepared and again provided with the sample number of the test panel.

7.4.4 If only a few panels of a particular plywood type, or very thick and large panels, are submitted for inspection, and if the effort involved in cutting these panels appears to be too great, then samples can also be taken from pieces cut off the edge of these panels. For this purpose, it is necessary, when trimming these panels, to put the edge cuttings aside.

7.4.5 The number of test panels is determined according to the following factors:

7.4.5.1 If continuous inspections by BKI in the manufacturing shop show that the production of the plywood panels appears to be reliable, and if the production is monitored continuously by suitable, automatic facilities or supervision, then it is not necessary to take test panels from each test batch.

7.4.5.2 It is sufficient to select approximately 2 % (by number) of the panels from the current production to be used as samples.

7.4.5.3 It shall be ensured that test panels cover all plywood thicknesses and types.

7.4.5.4 If production problems occur, or if the BKI surveyor has the impression that the production is not always reliable, then the surveyor can insist on the selection of a greater number of test panels.

7.4.6 If one or several test panels should exhibit inadequate values during the inspection, then an additional two panels from the same test batch shall be tested. If, once again, the minimum requirements are not satisfied during this inspection, then the complete test batch shall be rejected.

7.5 General quality of the panels

7.5.1 The general quality at the panels shall be determined by an external examination.

7.5.2 The internal quality shall be examined against the light provided by a suitable source of illumination of sufficient intensity in a well darkened room.

7.5.3 All panels up to a thickness which allows examination against light shall be subject to this inspection:

– Light timber, e.g. birch: up to 3.0 mm thickness,

– Darker timber, such as beech or okume (gaboon): up to 1.5 mm thickness.

7.6 Thickness deviations

Deviations in production, especially with regard to the thickness, shall comply with the requirements of the customer. If no other specifications exist, then the values listed in B.2 shall be used.

7.7 Moisture test

7.7.1 Two kiln-drying samples are used for determining the moisture of plywood. This shall be done in accordance with DIN 52375. The moisture content of the plywood should be 5 – 12 % ex works.

7.7.2 Measurements of the moisture content of plywood by means of electrical measuring instruments can only be approved if check measurements using the kiln-dried samples have shown approximately identical values.

7.8 Tensile strength

7.8.1 The strength of at least three samples parallel to and three samples at right angles to the fibre direction of the outer layers of each test panel shall be determined by means of tensile testing in a calibrated testing machine.

7.8.2 The tensile strength shall be determined in accordance with DIN 52377, using the test pieces specified therein.

7.8.3 The average value of the results for the same test panel is taken as the result of the test.

7.9 Tensile lap-shear test

7.9.1 The tensile lap-shear test shall be carried out in accordance with DIN 53255.

7.9.2 The tensile lap-shear strength shall be determined with at least five samples from each test panel in a wet condition by shearing off the bonded area in a calibrated testing machine, as well as with two boiling samples of 10 cm x 10 cm dimensions:

– Samples for 3-ply panels in accordance with Fig. 1.2

– Samples for 5-ply panels in accordance with Figs. 1.3 and 1.6

– Samples for 7-ply panels in accordance with Figs. 1.4 and 1.7

– Samples for 9-ply panels in accordance with Fig. 1.5.

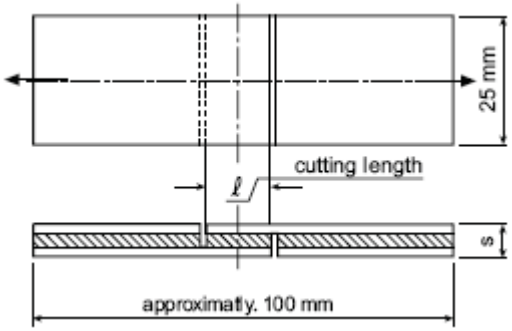


Fig. 1.2 Longitudinal sample for a 3-ply plywood panel

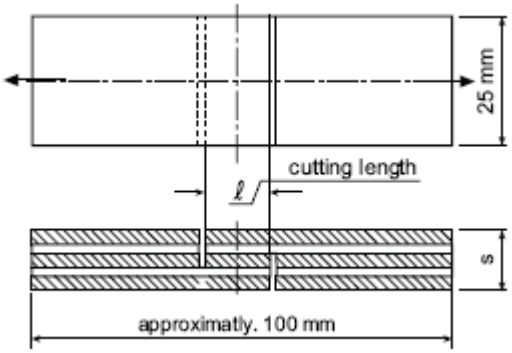


Fig. 1.3 Transverse sample for a 5-ply plywood panel

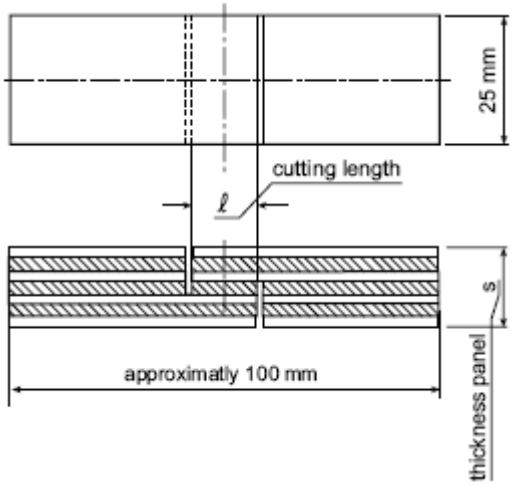


Fig. 1.4 Longitudinal sample for a 7-ply plywood panel

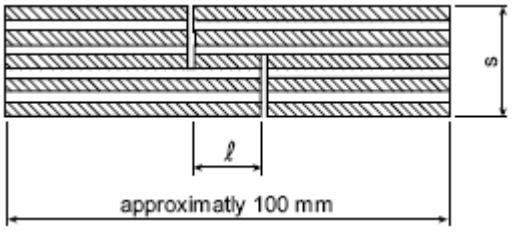


Fig. 1.5 Transverse sample for a 9-ply plywood panel

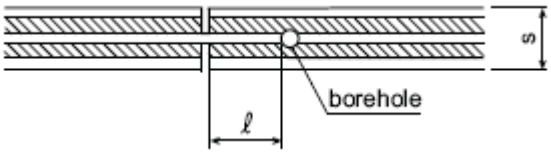


Fig. 1.6 Longitudinal sample for a 5-ply plywood panel

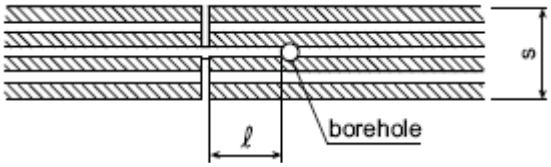


Fig. 1.7 Transverse sample for a 7-ply plywood panel

7.9.3 Recommended values for the routing lengths of the adhesive samples

The tested bonding area shall be small enough so that no wood shake occurs, and on the other hand shall be large enough so that the layers do not detach themselves too easily. See Table 1.5 for recommended lengths.

Table 1.5 Recommended length of the adhesive

Panel Thickness = s in mm	Up tp 0.8	1 - 2	2.5	3	4	5	6	8	10 - 14	16 - 20
Cutting length = l in mm	3	4	5	5	6	7	8	9	10	12
Glue surface for the sample acc. Fig.1.2, 1.3, 1.4 and 1.5 = cutting length 1 x width of sample,										
Glue surface for the sample acc. Fig.1.6 and 1.7 = 2 x cutting length 1 x width of sample.										

7.9.4 Adhesive samples of 5-ply and multi-ply panels having thin veneer thickness which cannot, or cannot easily, be penetrated in accordance with Figs. 1.6 and 1.7, shall be prepared in accordance with Figs. 1.3, 1.4 and 1.6; however, the fibres of the outer layers shall be in the transverse direction in the case of 5-ply panels, and parallel to the longitudinal direction of the sample in the case of 7-ply panels. Routing of three or four layers shall be performed on each side.

7.9.5 The samples shall have been immersed in water prior to the test for a sufficient period of time to ensure complete soaking.

Recommended values for soaking at room temperature (15 – 20°C):

– 24 hours for samples up to 2 mm thickness

– For thicknesses greater than 2 mm, the required time is determined by linear extrapolation.

Soaking of the samples may be substituted by three hours of boiling (three-hour immersion in boiling water).

7.9.6 The strength after soaking or after boiling of the samples should be determined in a wet state and shall be at least 2 N/mm^2.

7.9.7 Isolated values may be up to 10 % below this requirement.

7.9.8 In addition, a three-hour boiling test shall be performed twice on two 10 cm x 10 cm samples from each test panel. The samples shall be first boiled for three hours in water and then dried at 60 °C. After this, they shall again be boiled for three hours, cooled in warm water for two hours at 20 °C and then, in a wet

state, shall either be manually or with suitable equipment bent several times back and forth until they break. In doing so, there shall be no sign of loosening of the individual veneer layers, no embrittlement or unfavourable appearance of the glue joint.

7.9.9 If the BKI surveyor notices anything unusual in this respect, he shall then increase the number of the tests and carry them out on the panels in question.

7.9.10 In the case of bonding with phenolic resin, boiling tests may be omitted at the discretion of the BKI surveyor.

7.10 Additional tests

7.10.1 If the BKI surveyor has any doubts regarding the production and, in particular, the correct bonding of the plywood panels and its scarf jointing, then he is authorized to subject the test batch to additional tests. For example: prising-open tests, knocking-off tests, bending tests, warping tests, soaking tests etc.

8. Marking and stamping

8.1 Each panel which satisfies these Rules and is approved shall be provided with the following stamp:

8.1.1 Stamping by the manufacturer:

– Sign or mark of the manufacturer

– Thickness of the panel in mm and the timber used

– Letters which identify the type of bonding e.g.

T = bonded with Tego film

PH = bonded with phenolic resin

M = bonded with melamine resin

R = bonded with resorcinol resin

As an alternative, the type of bonding can be identified by "BFU 100".

8.1.2 Stamping by Biro Klasifikasi Indonesia:

– A stamp that identifies the grade KI I or II, the number of the test batch, the year of testing

– The stamps should be applied by means of a roller stamp diagonally across the panel on the side of lesser quality.

8.2 Since inspection is only carried out randomly, the surveyor is entitled to reject panels which have already been stamped, if they should prove to be defective.

8.3 BKI is entitled to stop providing stamps if production defects occur continually.

9. Certificates

9.1 Biro Klasifikasi Indonesia issues certificates for tested and approved plywood panels, and these certificates are handed over to the manufacturer or customer.

9.2 The certificate specifies, among other things, the plywood type, the number of plywood panels inspected, the stamping and, if requested, the average values of the test results.

10. Storage of the plywood panels

10.1 Finished plywood panels placed in storage shall be kept in closed rooms.

10.2 The plywood panels shall only be placed in horizontal stores that are at least 30 cm above the ground and from the walls, in order to avoid the effects of moisture.

10.3 The individual stacks shall be protected against moisture from one side by covering panels.

10.4 Non-compliance with these storage requirements can lead to previous tests being declared invalid.

E. Joining of Wood Materials

1. Laminated and multi layered components

1.1 In order to reduce variations in the characteristic values of wood and therefore to arrive at reasonable safety factors to be applied in designing structural elements, the wood is homogenized by means of lamination. Laminated components are bonded components consisting of individual layers (at least three) of sawn timber which have the same grain direction.

1.2 Multi-layered components are bonded components in which the individual layers (at least three) consist of sawn timber and have different grain directions. The thickness of the individual laminates depends on the shape of the components to be laminated. However, the laminate thicknesses shall not, if possible, be less than 5 mm and shall not exceed 25 mm in the case of curved parts. In the case of straight parts, the laminate thickness shall not be more than 40 mm.

1.3 Adhesives may only be used that are resistant to cold and boiling water and that in the bonded joint have the same strength as that of the wood (see also C and D). A precondition for the carrying out of gluing procedures is the availability in the workshops of temperature and humidity controls as well as clamping facilities.

1.4 The moisture of the wood shall be 12 – 15 % at the time of bonding; but must not exceed 18 %. Efforts should be made to keep the glued joint as thin as possible (0,1 – 0,2 mm).

1.5 Since transverse compressive stresses during subsequent swelling of the wood are less damaging than transverse tensile stresses brought about by subsequent volume contraction, it is recommended that the timber be dried to an average moisture content that is the same as, or just below, the average moisture content of the component.

1.6 If adhesives on a formaldehyde basis are used (e.g. for boatbuilding timber), then a pre-drying time for the moist joining surface for 5 – 10 minutes may be necessary to enable low-molecular substances to escape.

1.7 Sufficiently long clamping times shall be adhered to, depending on the bonding temperature. In the case of curved or welded parts, the clamping time shall be extended accordingly.

2. Scarf jointing

2.1 The joint ends shall be precisely joined in order to avoid faulty gluing or other defects.

2.2 Fig. 1.8 A illustrates the correct method. Fig. B depicts the incorrect method; it is especially unsuitable, as faulty gluing occurs frequently because of insufficient pressing power. The method illustrated in Fig. C is also wrong and causes a variety of defects. In this case, particularly when sanding plywood panels down until they are smooth, the outer layers are sanded away excessively.

2.3 The minimum pressing power shall not fall below 4 kg/cm².

2.4 Glued scarf-jointing of solid wood shall have a chamfer length which is eight times the panel thickness.

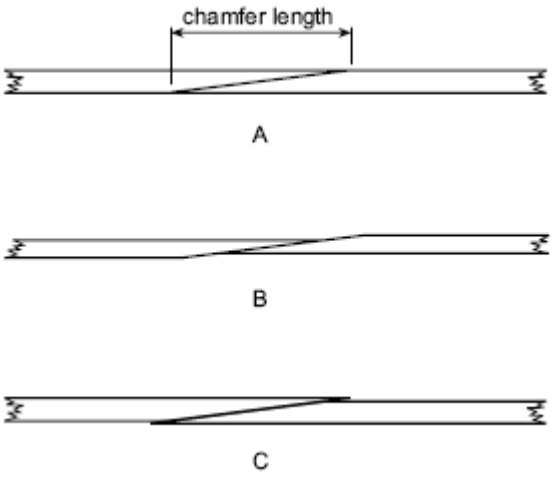


Fig. 1.8 Scarf joints across the thickness

2.5 For glued scarf-jointing of plywood, the ratio of the plywood thickness to chamfer length shall be as follows:

– For panels up to 10 mm : at least 1:10

– For panels over 10 mm : at least 1:8

2.6 Further information is given in the VG 81243 Standard (Wood Bonding in Wood Boatbuilding).

F. Wood Protection

1. All timber (with the exception of the timber of the durability group I, Table 1.2) shall be protected by several coats of suitable protective paint, or by means of impregnation with a proven wood preservative, against fungi and insect infestation. Impregnation is the preferred method for interior surfaces of the boat's components which are exposed to water or weather (outer e. g. skin, deck, superstructure) and which have received a coat of paint impervious to vapour pressure.

2. All plywood parts shall be protected by several coats of paint or varnish. Special attention shall be paid to plywood edges and drill-holes by pretreating them with recognized and proven edge protection coatings.

Section 2

Requirements for the Core Materials of Sandwich Laminates

A. Cross-Cut Balsa Wood[1)]

1. General

1.1 For material approval, the basic conditions listed in Chapter 1- Fibre Reinforced Plastics and Bondings, Section 2, A.1 shall apply.

1.2 A general description of the core material shall be provided. The basic properties shall be verified through the test certificate of a recognized testing body.

2. Specification

2.1 The following details are required for a general description:

– Commercial name

– Treatment of the wood

– Storage conditions

2.2 Through the test certificate of a recognized testing body, the following values shall be verified:

– Raw density (DIN 52182), 3 samples

– Moisture content (ISO 3130), 3 samples

– Compressive strength II, ⊥ (DIN 52185), 6 samples

– Modulus of elasticity (compression) II, ⊥ (DIN 52185), 6 samples

– Shear strength (DIN 53294), 6 samples

– Shear modulus (DIN 53294), 6 samples

(where: II is parallel to the grain, and ⊥ is perpendicular to the grain of the wood).

2.3 The following shall apply as minimum properties:

–	Apparent density	96	kg/m^3
–	Compressive strength II	5.0	MPa
–	Compressive strength ⊥	0.4	MPa
–	Modulus of elasticity(compression) II	2275	MPa
–	Modulus of elasticity(compression) ⊥	35	MPa
–	Shear strength	1.1	MPa
–	Shear modulus	105	MPa

2.4 The moisture content shall be 12 ± 2%.

2.5 The tests shall be performed on samples which exhibit none of the flaws which are still permissible for processing. The surfaces must be plane and sanded. As the testing environment, the standard climate 23/50 (23 °C / 50 % relative humidity) shall be used.

[1)] Cross-cut or cross-grained wood is timber which has been cut cross the grain.

This page intentionally left blank

RULES FOR THE CLASSIFICATION AND CONSTRUCTION

PART 1. SEAGOING SHIPS

VOLUME XIV
RULES FOR NON–METALLIC MATERIALS
2014 EDITION

CHAPTER 3 - GUIDELINES FOR ELASTOMERIC ADHESIVES AND ADHESIVE JOINTS

Biro Klasifikasi Indonesia
Jl. Yos Sudarso No. 38-40, Tanjung Priok
Jakarta 14320
www.bki.co.id
rules@bki.co.id

This page intentionally left blank

Table of Contents

CHAPTER 3 - GUIDELINES FOR ELASTOMERIC ADHESIVES AND ADHESIVE JOINTS

Section 1 - Requirements for the Adhesives and Adhesive Joints ..... 1 / 6
A. General ..... 1 / 6
B. Approval of the Adhesives ..... 2 / 6
C. Requirements for the Adhesive-Processing Shops and the Personnel ..... 2 / 6
D. Execution of the Bonding ..... 2 / 6
E. Manufacturing Surveillance at the Applicator ..... 4 / 6

Section 2 - Approval of Elastomeric Adhesives ..... 1 / 3
A. Requirements ..... 1 / 3

Annex A - Applicable Standards and Guidelines ..... A-1 / 1
A. Applicable Standards and Guidelines for Section 1 ..... A-1 / 1
B. Applicable Standards and Guidelines for Section 2 ..... A-1 / 1

Annex B - Example for a Documentation Accompanying Each Stage of Production / Procedure Test ..... B-1 / 4
A. Documentation ..... B-1 / 4
B. Check of the Bonded Joints (in the Case of Documentation Accompanying each Stage of Production) ..... B-3 / 4
C. Testing of the Bonded Joints (in the Case of a Procedure Test) ..... B-4 / 4

This page intentionally left blank

Section 1

Requirements for the Adhesives and Adhesive Joints

A. General

1. Parts and components of metal, plastic and other materials may be bonded using elastomeric adhesives. The requirements concerning fire protection shall always be clarified for each individual case.

2. Elastomeric adhesive joints within the sense of these Rules are adhesive joints which, in the tensile lap shear test, can endure a shear angle of more than 100 % statically for a brief period at room temperature. Therefore an elastomeric adhesive is used which possesses elastomeric properties in the cured state.

3. Elastomeric adhesives do not offer any permanent protection against corrosion.

4. The adhesives and the surface treatment of the bonding surfaces may not adversely affect the material properties of the parts to be joined, i.e. the function of the parts after joining and the bonded joint itself shall not be impaired.

5. Depending upon the application, the adhesives shall exhibit a high durability, e. g. resistance against moisture (including seawater), acids, alkalis, fuel, oil, grease and UV radiation.

6. It must be possible to use the adhesives permanently within the temperature range from -20 °C to + 60 °C.

7. For the elastic bonding of structural components and components which are integrated into the structure, only adhesives approved by Biro Klasifikasi Indonesia (BKI) shall be used.

8. The field of application of these Rules are limited to the bonding of structural components and load-bearing components which are integrated into the structure, as well as components of relevance to ship safety. Depending on the area of application, an adhesive approval according to class A or class B will be required. For better understanding, the areas of application for class A and B are given below by way of example:

Class A:

Bonded joints under increased mechanical stressing (high strength with medium compliance):

– panes of insulating glass, single-pane safety glass or laminated safety glass

– rails for fastening seats

– door frames

Class B:

Bonded joints under medium mechanical stressing (high compliance with medium strength):

– transparent plastic sheets (single panes with dimensions under 0.5 m x 0.5 m)

– wind-break walls

The subdivision into class A or B shall be made in consultation with BKI.

For bonded joints which are subjected to such high dynamic stresses that these form the decisive parameter for the bond, material tests in excess of the approval tests shall be performed (Section 2).

B. Approval of the Adhesives

1. The manufacturer of the adhesive, or the authorized representative, shall apply to Biro Klasifikasi Indonesia for approval. Here it shallbe stated whether the application is for approval according to class A or class B.

2. Approval is granted if the adhesive meets the requirements prescribed in Section 2. Evidence that the requirements have been met shall be provided by means of a test certificate issued by an accredited testing laboratory.

3. Tests acknowledged by other classification societies can also be approved after consultation, provided that such tests comply with the requirements of these Rules.

C. Requirements for the Adhesive-Processing Shops and the Personnel

1. General

1.1 All production facilities, storerooms and the operational equipment shall fulfill the requirements of the responsible safety authorities and employer's liability insurance associations. The manufacturer shall bear the sole responsibility for compliance with these requirements.

2. Storage

2.1 Adhesives shall be stored in accordance with the manufacturer's specifications. The temperature of the storerooms shall be recorded continuously by means of thermographs.

2.2 Storage shall be arranged in such a way that the identification of the materials, their storage conditions and the maximum period of storage (expiry date) as prescribed by the manufacturer are clearly visible. Adhesives whose duration of storage has exceeded the expiry date shall be removed immediately from the stores.

3. Production facilities

3.1 Production facilities shall be arranged so that the requirements for the processing and curing of the adhesive systems with regard to environment, cleanliness and industrial hygiene can be fulfilled.

3.2 Ventilation facilities shall be arranged in such a manner that fumes of solvents (e. g. of primers) are removed properly and targeted away, and also that no inadmissible workplace concentrations (MAC values) occur.

3.3 The workplace shall be illuminated adequately and suitably, but precautionary measures shall be taken to ensure that the curing process is not impaired through either sunlight or lighting equipment.

4. Personnel

4.1 The pre-treatment of the joining surfaces and the bonding of structural components shall only be performed by persons with adequate skills and professional knowledge. This professional knowledge shall be documented by means of certificates from the corresponding training courses.

D. Execution of the Bonding

1. General

1.1 The required characteristics of bonded joints for load-bearing parts shall be verified, using a procedure test to be agreed upon for each individual case. The scope of the required tests shall be determined in consultation with BKI. An example for a procedure test is given in Annex B.

1.2 For the processing of the adhesives, the instructions of the adhesives manufacturer as well as the requirements of the responsible safety authorities and employer's liability insurance associations shall be observed in addition to these Rules. In cases of conflict in requirements, BKI shallbe consulted.

1.3 During the bonding process, the processing time of the adhesives as specified by the manufacturer shall not be exceeded. If such a time is not specified, qualification tests shall be carried out to determine the permissible pot-life (in the case of thermosetting resin adhesives) or the skin-forming times (in the case of single-component systems) for the relevant environment and batch quantities. On the basis of these values, the processing times shall then be determined by agreement with BKI.

1.4 Appliances for joining the components shall be constructed so that the admissible deformations of the components, as specified by the adhesive manufacturer and the designer, are not exceeded during the curing process.

1.5 Fibre-reinforced plastics, thermosetting resins and painted components shall only be bonded when fully cured.

1.6 For the elastic bonding of plastics with each other or with other materials, low-solvent adhesives shall be used.

2. Structural design

2.1 A design suitable for bonding shall be used which, as far as possible, avoids peeling moments and forces and for which, under long-term static loading, no creep occurs that could impair the function of the bonded joint.

2.2 If low stresses is required, in the parts in case of the deformation of the parts to be joined the bonding layer shall be thick. The stresses for large deformations shall be kept low through thick bonding layers. Whether thicknesses of less than 3 mm are admissible shall be clarified in each individual case with BKI. To ensure that the bonding layer is of uniform thickness, flexible spacers (if possible with the same Shore A hardness as the fully cured adhesive) shall be provided.

2.3 The application limits for the adhesive, shall be observed with regard to its resistance to certain temperatures and media, as specified by the manufacturer.

2.4 If necessary, suitable measures shall be taken to protect the edges of the bond against the direct effects of aggressive media (e. g. hydraulic oil), moisture and UV radiation.

2.5 The design shall provide for proper accessibility of the bonding layer for an inspection and for possible repair work.

3. Surface pre-treatment

3.1 The surface pre-treatment shall be arranged so that a surface with defined and reproducible properties is obtained.

3.2 A surface treatment procedure shall be applied, that is suitably effective for the adhesive system and for the parts to be bonded. Furthermore, steps shall be taken to ensure that the properties of the surface do not deteriorate before the bonding process is started.

3.3 If there are coatings on the surface of the materials to be bonded which impair adhesion (e. g. skin-forming agents in UP resins), these layers shall be removed by adopting suitable procedures.

3.4 If bonded joints are used in an environment with corrosive media, the parts to be joined and the joining surfaces shall be treated with a corrosion protection system. The compatibility of the corrosion protection with the adhesive system shall be verified within the procedure test.

3.5 In many cases, an increase in the interfacial strength can be achieved through the application of specially matched primers. For each individual object, the use of primers shall be coordinated with the adhesive supplier.

3.6 If primers or degreasing agents are used, due attention shall be paid to ensuring adequate compatibility with the part to be bonded. The manufacturer's specifications for the evaporation time shall be observed.

3.7 The suitability of the surface treatment for the chosen adhesive shall be verified by means of a suitable test using the original substrate materials. An example for the assessment of the surface treatment is the peeling test following climatic conditioning.

3.8 Various surface pre-treatments for metals and plastics are listed in the VDI (Association of German Engineers) guidelines 2229 and 3821.

4. Processing

4.1 The adhesives intended for processing and the parts to be joined shall be brought into the production shops in good time to ensure proper acclimatization to the processing temperature ($\Delta T \leq 2°C$).

4.2 During bonding, a room temperature between 10°C and 30°C and a maximum relative humidity of 70% shall be maintained. During the curing process, only the temperature limits need be observed. If these environmental conditions cannot be provided, the processing conditions shall be coordinated with the adhesive manufacturer and BKI.

4.3 When using primer systems, the venting evaporation time specified by the manufacturer shall be observed. Similarly, between a mechanical pre treatment of aluminium and the application of adhesive or primer, a delay of 20 to 120 mins. (depending on the alloy type) shall be observed.

4.4 If possible, the adhesive shall be applied to the joining surfaces immediately after the surface pre-treatment has been concluded.

4.5 The adhesive shall be applied uniformly and free of voids onto the parts to be joined. Care shall be taken to ensure good wetting of the joining surfaces.

5. Curing

5.1 The required curing depends upon the environmental conditions (temperature/humidity, and the ratio of surface area to volume of the adhesive joint, or diffusion path for single-component adhesives). With increasing length of the diffusion path, the curing speed is reduced progressively. The manufacturer's documentation shall be consulted for reference values.

5.2 For the curing of single-component systems, measures shall be taken to ensure a relative humidity of at least 30 %, since these adhesives require water to cure properly. If this cannot be ensured, the adhesive shall be wetted after a skin has formed, e. g. by creating a fine mist of water at regular intervals in the vicinity of the adhesive bond using a spray bottle.

5.3 Bonded parts shall be loaded by their own weight or additional loads only after the adhesive has undergone sufficient curing.

E. Manufacturing Surveillance at the Applicator

1. General

1.1 For the bonding of components, manufacturing surveillance consists of the quality control of the

materials used in bonding, the monitoring of the bonding procedure and the inspection of the quality of the finished components.

1.2 In the case of manufacturing surveillance, a distinction is made between internal and third-party (external) surveillance. In the sense of these Rules, third-party surveillance means periodic and random checks by BKI of the internal surveillance as well as of the component quality.

1.3 Within the scope of manufacturing surveillance, BKI reserves the right to carry out inspections in the production facilities without giving prior notice. The manufacturer shall grant the inspectors access to all areas used for production, storage and testing, and shall present all documentation concerning records and tests carried out.

1.4 For production facilities with a certified quality management system according to ISO 9000, the scope of third-party surveillance can be reduced.

2. Incoming inspection

2.1 As part of the incoming inspection, a check shall be made to ascertain whether the delivered adhesive bears a valid approval by BKI.

2.2 The goods shall be stored in accordance with the requirements of the manufacturer.

3. Production surveillance

3.1 Details of the working sequences needed for the execution of the adhesive joint shall be described in a work instruction which accompanies each stage of production and is signed by the respective person in charge. Compliance with the required work sequences shall be documented at each stage of production (Annex B).

3.2 Production surveillance of the bonding of the components shall be carried out constantly by the internal quality department. The scope shall be stipulated in an inspection and test plan, and signed by the persons in charge.

3.3 The materials used in the production shall be documented. Parameters relevant for the quality (e. g. temperature and humidity) shall also be recorded in the production documentation.

3.4 A deferred sample shall be taken from each batch of two-component thermosetting adhesive that is mixed, and this shall be labeled, cured and stored for at least 2 years. If many small batches are removed from one packing unit on a single day, it is permissible to use a dosing report from the second batch and to dispense with the deferred samples. The deferred samples shall be subjected to random testing of their degree of curing, and the results shall be documented. The deferred samples and the dosing report are intended for finding errors in mixing and for detecting inadequacies in the curing cycle.

3.5 Parallel to the bonding process, reference samples shall be produced on which the peeling tests are to be performed. The reference samples shall be identical to the parts to be bonded with regard to base material, surface structure, adhesive, and pretreatment of the bonding surfaces. The reference samples serve to check the compliance with the required surface structure and the pre-treatment quality, as defined by qualification tests. The number of reference samples shall be agreed with BKI for each individual case. Through the use of reference samples, the scope of the structural tests can be reduced.

3.6 The documentation accompanying each stage of production shall be archived for at least 10 years.

4. Testing

4.1 During and at the end of the bonding process, the parts to be joined, the joining surfaces and the adhesive shall be subjected to a visual inspection. Here special attention shall be paid to good wetting of the

joining surfaces with the adhesive, and also to voids, discolouration, stress cracking, damage or similar defects.

4.2 The quality of the bond shall be determined with non-destructive testing methods, if possible. Ultrasonic testing can be used to determine the presence of adhesive, the thickness of the bonding layer, large voids, and any gap between adhesive and joining surface. By knocking (tapping) on the bonded joint, experienced inspectors can find defects in certain cases. Further testing methods include radiographic inspection and sound emission analysis. However, with non-destructive testing methods it is not possible to detect variations in the adhesion between the adhesive and the joining part.

4.3 In the case of series production, random tests of completed component bonds shall be performed in coordination with BKI.

Section 2

Approval of Elastomeric Adhesives

A. Requirements

1. General

1.1 The manufacturer of the adhesive, or an authorized representative, shall apply to Biro Klasifikasi Indonesia for approval of an elastomeric adhesive. The following shall be appended to the application:

– product description

– safety data sheet

– storage and processing instructions

– copy of the test certificate issued by an accredited test laboratory.

– evidence of a quality management system according to ISO 9000, if such a system exists.

– written confirmation of the manufacturer stating that the sample adhesive is identical to the adhesive for which the approval is being sought, and that these Rules was observed during the manufacture of the sample.

1.2 The minimum properties required by BKI for the tests shall be attained by all samples.

1.3 If the test results of individual samples are unsatisfactory, the following conditions shall be observed (for a basic quantity of 6 tests):

– If one or two samples exhibit inadequate test results, the tests shall be repeated with double the number of samples.

– If three or more samples exhibit inadequate test results, the test can be repeated on newly manufactured samples, provided that BKI agrees to renewed testing.

– Even if only one sample exhibits inadequate results during the repeat tests, approval will not be granted.

1.4 If the material conforms to the requirements of these Rules, an adhesive approval according to class A or B will be granted. This will be limited to a period of five years, whereby extensions of validity are possible.

1.5 Modifications or other changes in the material shall be reported to BKI without delay. A decision on the continued validity of the material approval will then be taken in each individual case.

1.6 By means of suitable quality assurance measures, the manufacturer shall ensure that the properties specified under item 2 and the minimum properties required under item 3 are observed. If this cannot be guaranteed, then BKI reserves the right to suspend or retract the approval.

1.7 During the validity period of adhesive approvals, BKI reserves the right to request or perform checks on the material properties. If inadequate results are obtained in comparison to the values submitted, the material approval will lose its validity.

2. Requirements

2.1 General

2.1.1 For an adhesive approval, the basic prerequisites listed under item 1 shall apply.

2.1.2 A general description of the adhesive shall be given. The fundamental properties of the cured adhesive shall be verified by the test certificate of an accredited test laboratory.

2.1.3 The tests shall be performed according to the standards listed below. In exceptional cases, equivalent standards of other countries can also be applied.

2.1.4 Upon request by the applicant, further tests (e.g. fatigue tests) can be included in the approval. These tests will then be listed separately on the certificate.

2.2 Description

2.2.1 A description which permits an unambiguous identification of the adhesive is required:

- type of adhesive
- manufacturer
- trade name
- storage conditions
- processing and curing guidelines
- volume shrinkage during curing

2.3 Properties of the adhesive

2.3.1 The following shall be stated for the ready-to use condition:

- density, e. g. ISO 1675
- pot-life for two-component products (100 g mixture in a beaker) at 10°C and 30 % relative humidity (RH) and also at 30°C and 70 % RH.
- skin-forming time at 10°C and 30 % RH and also at 30°C and 70 % RH.

2.3.2 For the curing process, the following shall be given:

- curing distance at 10°C / 30 % RH and 30°C /70 % RH after 24 hours, and also after 3, 7 and 28 days, for single-component systems.
- tensile stress at yield according to DIN 53504, measured after 24 hours, and 2, 4 and 7 days, for two-component systems. For one series, storage shall take place at 10°C and for the other at 30°C. Testing climate: 23 °C / 50 % RH
- volume shrinkage, e.g. according to DIN 52451.

2.3.3 For the cured state, the following properties shall be stated:

2.3.3.1 The following shall be specified for the adhesive (by the manufacturer):

- shore A hardness according to DIN 53505
- qualitative assessment of the resistance to certain media, e.g. against
  - seawater
  - UV radiation
  - fuel
  - mineral oil
  - hydraulic fluid
  - grease
  - acid and alkaline solutions

2.3.3.2 For the adhesive, the following properties shall be verified by means of a certificate issued by an accredited testing body:

- modulus of torsional shear according to DIN EN ISO 6721-2B (min. temperature range -30°C to +80°C)
- tensile stress at yield and fracture strain according to DIN 53504 at -20°C, plus 60°C and standard climate (23°C and 50 % RH)
- tear propagation resistance according to DIN 53515 for the standard climate

2.3.3.3 The following shall be determined at bonded joints with an adhesive layer thickness of 3 mm for the standard climate (in deviation from DIN EN 1465, test samples with a test-sample thickness of at least 10 mm shall be used, with an overlap length of 20 mm and a testing speed of 5 mm/min):

- tensile lap-shear test according to DIN EN 1465
- Furthermore, a long-duration tensile lap-shear test (based on DIN EN 1465) shall be performed to determine the strain in creep. Here the samples shall be loaded with an average tensile lap-shear stress of 0.25 MPa (class A) in a standard climate and with 0.15 MPa (class A) at 60 °C for at least three months. These measurements can be performed in the manufacturer's own laboratory, if the deformations occurring during the tensile lap-shear tests at 0.25 MPa (class A) and 0.15 MPa (class A) were specified by the accredited testing body and if these correspond to the manufacturer's own measurements. In the case of adhesives for which an approval according to class B is sought, the manufacturer shall specify minimum properties for 23 °C and 60 °C, and verify them within the long duration tensile lap shear test.
- As part of a relaxation test (based on DIN EN 1465), the samples shall be stored for 90 days with a constant elongation of 30 % (class B at RT) with conditioning according to DIN 50017-KFW. Temperature-related changes in elongation are permissible. In the case of adhesives for which approval according to class A is sought, a minimum property shall be specified by the manufacturer and verified within the relaxation test.

3. Minimum properties

3.1 For an adhesive approval, the following minimum properties acc. Table 2.1 shall be attained:

Table 2.1 Minimum properties to be achieved

	Standard	**Class A**	**Class B**
Shore A	DIN 53505	≥ 45	≥ 30
Facture strain at –20 °C	DIN 53504	≥ 50 %	≥ 100 %
Tensile stress at yield for +60 °C	DIN 53504	≥ 1.5 MPa	≥ 0.6 MPa
Tear propagation resistance	DIN 53515	≥ 4 N/mm	≥ 4 N/mm
Tensile lap-shear strength	DIN EN 1465	≥ 2 MPa	≥ 0.7 MPa
Values for the long-term tensile lap-shear test at 23°C / 50 % rel. humidity at 60 °C	Based on DIN EN 1465	0.25 MPa[1)] 0.15 MPa[1)]	Specified by manufacturer
Relaxation test after 90-day conditioning	Based on DIN EN 1465 and DIN 50017	Specified by manufacturer	30 % ± 1 %

[1)] No failure may take place within the long-duration shear tension tests. The strain-in-creep values that are determined shall be specified versus the time.

This page intentionally left blank

Annex A

Applicable Standards and Guidelines

A. Applicable Standards and Guidelines for Section 1

Table A.1 Applicable Standards and Guidelines for Section 1

Standard	Part	Title	Date of issue
DIN EN 10204		Metallic products - Types of inspection documents	01.2005
VDI 2229		Metal bonded joints - Instructions for design and production	06.1979
VDI 3821		Adhesive bonding of plastics	09.1978

B. Applicable Standards and Guidelines for Section 2

Table A.2 Applicable Standards and Guidelines for Section 2

Standard	Part	Title	Date of issue
DIN EN 1465		Determination of tensile lap-shear strength of rigid-to-rigid bonded assemblies	07.2009
DIN EN ISO 1675		Plastics; Liquid resins; Determination of density by the pyknometer method	10.1998
DIN EN ISO 6721	2	Plastics - Determination of dynamic mechanical properties - Part 2: Torsion-pendulum method	09.2008
DIN 50017		Atmospheres and their application ; Condensation water test atmospheres	10.1982
DIN 52451	1	Testing of sealing materials for buildings - Part 1: Determination of change in mass and volume of self-levelling joint sealants	01.2007
DIN 53504		Testing of rubber; determination of tensile strength at break, tensile stress at yield, elongation at break and stress values in a tensile test	10.2009
DIN 53505		Testing of rubber - Shore A and Shore D hardness test	01.2000
DIN 53515		Determination of tear strength of rubber elastomers and plastic film using Graves angle test piece with nick	01.1990

This page intentionally left blank

Annex B

Example for a Documentation Accompanying Each Stage of Production / Procedure Test

A. Documentation

1. Materials used

1.1 Joining part no. 1 Manufacturer : _____

Material designation: _____ Batch No.: _____

Surface condition: _____

Joining part no. 2 Manufacturer : _____

Material designation: _____ Batch No.: _____

Surface condition: _____

1.2 Cleaning agent Manufacturer : _____

Trade name: _____ Batch No. _____

Basis : _____ Expiry date. _____

1.3 Mechanical surface treatment agents

☐ Sanding: Sandpaper grade: _____

☐ Blasting: Grit-blasting agent: _____

Grade : _____

1.4 Primer / Manufacturer _____

Coupling agent / Trade name: _____ Batch No. _____

Activators Basis: _____ Expiry date: _____

1.5 Adhesive / Manufacturer _____

Coupling agent / Trade name: _____ Batch No. _____

Activators Basis: _____ Expiry date: _____

2. Bonding process

2.1 Surface preparation

Person responsible: _____ _____

(Signature)

2.1.1 Cleaning of the surface

Date: _____ Location: _____ Time: _____

2.1.2 Mechanical surface pre-treatment

☐ not performed (e. g. in case of an anodised surface)

☐ grit-blasting

Date: _____ Location: _____ Time: _____

Contamination level of blasting medium: ☐ low
☐ as new
☐ new

☐ Sanding
☐ by machine
☐ by hand

Date: _____ Location: _____ Time: _____

2.1.3 Cleaning or post-treatment of the surface

Date : _____ Type : _____

Location : _____ Time : _____

2.1.4 Application of primer

☐ not performed
☐ performed

Date: _____ Location: _____ Time: _____

2.2 Joining of the parts

Person responsible: _____ _____
(Signature)

2.2.1 Climatic conditions

Temperature of the joining parts : _____ Temperature of the adhesive: _____

Ambient temperature: _____ Relative humidity: _____

2.2.2 Time of bonding

Date: _____ Location: _____ Time: _____

2.2.3 Dimensions of the adhesive gap

Target: _____

Smallest dimension is: _____

Largest dimension is: _____

2.3 Curing of the bonded joints

Required climate (temperature and relative humidity)

Recording device for temperature and relative humidity was available and switched on?

☐ Yes
☐ no

B. Check of the Bonded Joints (in the Case of Documentation Accompanying each Stage of Production)

Person responsible: _____ _____
(Signature)

1. Visual inspection

Conspicuous features: ☐ yes ☐ No

If "yes", please describe the type of deviation(s) and what measures were taken.

_____

_____

_____

_____

_____

_____

_____

_____

2. Peeling test on reference sample with and without climatic conditioning

- Type of failure: comprising _____ % adhesion failure **without** conditioning
- Type of failure: comprising _____ % adhesion failure **with** conditioning

3. Remarks:

_____

_____

_____

_____

_____

_____

_____

_____

4. Check by adhesive bonding specialist

Person responsible: _____ _____
(Signature)

C. Testing of the Bonded Joints (in the Case of a Procedure Test)

1. Peeling test with and without conditioning

Three round beads of adhesive, with a diameter of 10 mm and a length of approx. 200 mm, shall be applied to the surface to be bonded. After complete curing of the adhesive in a standard climate (23 °C and 50 % relative humidity), the first adhesion test shall be conducted. Then the specimens shall be stored for 7 days at 23 °C in distilled water and for 2 hours in a standard climate. After this conditioning, the second adhesion test shall be conducted. Following this, an object-specific climatic conditioning shall be performed. The following types of climatic conditioning are recommended:

- For bonding to glass panes:
  Cataplasma test (7 days conditioning at 70°C and 100% relative humidity plus 1day at – 30°C and 1day at 23 °C and 50 % relative humidity), followed by an adhesion test.
- For interior bonding:
  ASTM D 1183 method B, followed by an adhesion test, repeated conditioning according to method B and again an adhesion test.
- For bonding outside or in the cargo area:
  ASTM D 1183 method D (depending on the ship's range of trade, the minimum testing temperature of -57°C can be increased after agreement with BKI Head Office), followed by an adhesion test, repeated conditioning according to method D and another adhesion test.

For the evaluation of the fracture, a statement on the relationship between adhesion failure and cohesion failure shall be made, and this shall be compared with results from test samples that have not been subjected to climatic conditioning.

If it is already known beforehand that the bonded joints will be exposed to special media (e.g. acids, alkalis or industrial cleaning agents), the specimens shall also be stored in these media and then subjected to an adhesion test.

2. Ageing of the test samples with subsequent tensile lap-shear test according to Section 2, A.2.3.3.3