

Rules for the Type Approval of Components of Composite Materials Intended for Hull Construction

Effective from 1 January 2023

GENERAL CONDITIONS

Definitions:

“Administration” means the Government of the State whose flag the Ship is entitled to fly or under whose authority the Ship is authorised to operate in the specific case.

“IACS” means the International Association of Classification Societies.

“Interested Party” means the party, other than the Society, having an interest in or responsibility for the Ship, product, plant or system subject to classification or certification (such as the owner of the Ship and his representatives, the ship builder, the engine builder or the supplier of parts to be tested) who requests the Services or on whose behalf the Services are requested.

“Owner” means the registered owner, the ship owner, the manager or any other party with the responsibility, legally or contractually, to keep the ship seaworthy or in service, having particular regard to the provisions relating to the maintenance of class laid down in Part A, Chapter 2 of the Rules for the Classification of Ships or in the corresponding rules indicated in the specific Rules.

“Rules” in these General Conditions means the documents below issued by the Society:

- (i) Rules for the Classification of Ships or other special units;
- (ii) Complementary Rules containing the requirements for product, plant, system and other certification or containing the requirements for the assignment of additional class notations;
- (iii) Rules for the application of statutory rules, containing the rules to perform the duties delegated by Administrations;
- (iv) Guides to carry out particular activities connected with Services;
- (v) Any other technical document, as for example rule variations or interpretations.

“Services” means the activities described in Article 1 below, rendered by the Society upon request made by or on behalf of the Interested Party.

“Ship” means ships, boats, craft and other special units, as for example offshore structures, floating units and underwater craft.

“Society” or “TASNEEF” means Tasneef and/or all the companies in the Tasneef Group which provide the Services.

“Surveyor” means technical staff acting on behalf of the Society in performing the Services.

Article 1

1.1. The purpose of the Society is, among others, the classification and certification of ships and the certification of their parts and components. In particular, the Society:

- (i) sets forth and develops Rules;
- (ii) publishes the Register of Ships;
- (iii) issues certificates, statements and reports based on its survey activities.

1.2. The Society also takes part in the implementation of national and international rules and standards as delegated by various Governments.

1.3. The Society carries out technical assistance activities on request and provides special services outside the scope of classification, which are regulated by these general conditions, unless expressly excluded in the particular contract.

Article 2

2.1. The Rules developed by the Society reflect the level of its technical knowledge at the time they are published. Therefore, the Society, although committed also through its research and development services to continuous updating of the Rules, does not guarantee the Rules meet state-of-the-art science and technology at the time of publication or that they meet the Society's or others' subsequent technical developments.

2.2. The Interested Party is required to know the Rules on the basis of which the Services are provided. With particular reference to Classification Services, special attention is to be given to the Rules concerning class suspension, withdrawal and reinstatement. In case of doubt or inaccuracy, the Interested Party is to promptly contact the Society for clarification.

The Rules for Classification of Ships are published on the Society's website: www.tasneef.ae.

2.3. The Society exercises due care and skill:

- (i) in the selection of its Surveyors
- (ii) in the performance of its Services, taking into account the level of its technical knowledge at the time the Services are performed.

2.4. Surveys conducted by the Society include, but are not limited to, visual inspection and non-destructive testing. Unless otherwise required, surveys are conducted through sampling techniques and do not consist of comprehensive verification or monitoring of the Ship or of the items subject to certification. The surveys and checks made by the Society on board ship do not necessarily require the constant and continuous presence of the Surveyor. The Society may also commission laboratory testing, underwater inspection and other checks carried out by and under the responsibility of qualified service suppliers. Survey practices and procedures are selected by the Society based on its experience and knowledge and according to generally accepted technical standards in the sector.

Article 3

3.1. The class assigned to a Ship, like the reports, statements, certificates or any other document or information issued by the Society, reflects the opinion of the Society concerning compliance, at the time the Service is provided, of the Ship or product subject to certification, with the applicable Rules (given the intended use and within the relevant time frame).

The Society is under no obligation to make statements or provide information about elements or facts which are not part of the specific scope of the Service requested by the Interested Party or on its behalf.

3.2. No report, statement, notation on a plan, review, Certificate of Classification, document or information issued or given as part of the Services provided by the Society shall have any legal effect or implication other than a representation that, on the basis of the checks made by the Society, the Ship, structure, materials, equipment, machinery or any other item covered by such document or information meet the Rules. Any such document is issued solely for the use of the Society, its committees and clients or other duly authorised bodies and for no other purpose. Therefore, the Society cannot be held liable for any act made or document issued by other parties on the basis of the statements or information given by the Society. The validity, application, meaning and interpretation of a Certificate of Classification, or any other document or information issued by the Society in connection with its Services, is governed by the Rules of the Society, which is the sole subject entitled to make such interpretation. Any disagreement on technical matters between the Interested Party and the Surveyor in the carrying out of his functions shall be raised in writing as soon as possible with the Society, which will settle any divergence of opinion or dispute.

3.3. The classification of a Ship, or the issuance of a certificate or other document connected with classification or certification and in general with the performance of Services by the Society shall have the validity conferred upon it by the Rules of the Society at the time of the assignment of class or issuance of the certificate; in no case shall it amount to a statement or warranty of seaworthiness,

structural integrity, quality or fitness for a particular purpose or service of any Ship, structure, material, equipment or machinery inspected or tested by the Society.

3.4. Any document issued by the Society in relation to its activities reflects the condition of the Ship or the subject of certification or other activity at the time of the check.

3.5. The Rules, surveys and activities performed by the Society, reports, certificates and other documents issued by the Society are in no way intended to replace the duties and responsibilities of other parties such as Governments, designers, ship builders, manufacturers, repairers, suppliers, contractors or sub-contractors, Owners, operators, charterers, underwriters, sellers or intended buyers of a Ship or other product or system surveyed.

These documents and activities do not relieve such parties from any fulfilment, warranty, responsibility, duty or obligation (also of a contractual nature) expressed or implied or in any case incumbent on them, nor do they confer on such parties any right, claim or cause of action against the Society. With particular regard to the duties of the ship Owner, the Services undertaken by the Society do not relieve the Owner of his duty to ensure proper maintenance of the Ship and ensure seaworthiness at all times. Likewise, the Rules, surveys performed, reports, certificates and other documents issued by the Society are intended neither to guarantee the buyers of the Ship, its components or any other surveyed or certified item, nor to relieve the seller of the duties arising out of the law or the contract, regarding the quality, commercial value or characteristics of the item which is the subject of transaction.

In no case, therefore, shall the Society assume the obligations incumbent upon the above-mentioned parties, even when it is consulted in connection with matters not covered by its Rules or other documents.

In consideration of the above, the Interested Party undertakes to relieve and hold harmless the Society from any third party claim, as well as from any liability in relation to the latter concerning the Services rendered.

Insofar as they are not expressly provided for in these General Conditions, the duties and responsibilities of the Owner and Interested Parties with respect to the services rendered by the Society are described in the Rules applicable to the specific Service rendered.

Article 4

4.1. Any request for the Society's Services shall be submitted in writing and signed by or on behalf of the Interested Party. Such a request will be considered irrevocable as soon as received by the Society and shall entail acceptance by the applicant of all relevant requirements of the Rules, including these General Conditions. Upon acceptance of the written request by the Society, a contract between the Society and the Interested Party is entered into, which is regulated by the present General Conditions.

4.2. In consideration of the Services rendered by the Society, the Interested Party and the person requesting the service shall be jointly liable for the payment of the relevant fees, even if the service is not concluded for any cause not pertaining to the Society. In the latter case, the Society shall not be held liable for non-fulfilment or partial fulfilment of the Services requested. In the event of late payment, interest at the legal current rate increased by 1.5% may be demanded.

4.3. The contract for the classification of a Ship or for other Services may be terminated and any certificates revoked at the request of one of the parties, subject to at least 30 days' notice to be given in writing. Failure to pay, even in part, the fees due for Services carried out by the Society will entitle the Society to immediately terminate the contract and suspend the Services.

For every termination of the contract, the fees for the activities performed until the time of the termination shall be owed to the Society as well as the expenses incurred in view of activities already programmed; this is without prejudice to the right to compensation due to the Society as a consequence of the termination.

With particular reference to Ship classification and certification, unless decided otherwise by the Society, termination of the contract implies that the assignment of class to a Ship is withheld or, if already assigned, that it is suspended or withdrawn; any statutory certificates issued by the Society will be withdrawn in those cases where provided for by agreements between the Society and the flag State.

Article 5

5.1. In providing the Services, as well as other correlated information or advice, the Society, its Surveyors, servants or agents operate with due diligence for the proper execution of the activity. However, considering the nature of the activities performed (see art. 2.4), it is not possible to guarantee absolute accuracy, correctness and completeness of any information or advice supplied. Express and implied warranties are specifically disclaimed.

Therefore, except as provided for in paragraph 5.2 below, and also in the case of activities carried out by delegation of Governments, neither the Society nor any of its Surveyors will be liable for any loss, damage or expense of whatever nature sustained by any person, in tort or in contract, derived from carrying out the Services.

5.2. Notwithstanding the provisions in paragraph 5.1 above, should any user of the Society's Services prove that he has suffered a loss or damage due to any negligent act or omission of the Society, its Surveyors, servants or agents, then the Society will pay compensation to such person for his proved loss, up to, but not exceeding, five times the amount of the fees charged for the specific services, information or opinions from which the loss or damage derives or, if no fee has been charged, a maximum of AED5,000 (Arab Emirates Dirhams Five Thousand only). Where the fees charged are related to a number of Services, the amount of the fees will be apportioned for the purpose of the calculation of the maximum compensation, by reference to the estimated time involved in the performance of the Service from which the damage or loss derives. Any liability for indirect or consequential loss, damage or expense is specifically excluded. In any case, irrespective of the amount of the fees charged, the maximum damages payable by the Society will not be more than AED5,000,000 (Arab Emirates Dirhams Five Millions only). Payment of compensation under this paragraph will not entail any admission of responsibility and/or liability by the Society and will be made without prejudice to the disclaimer clause contained in paragraph 5.1 above.

5.3. Any claim for loss or damage of whatever nature by virtue of the provisions set forth herein shall be made to the Society in writing, within the shorter of the following periods: (i) THREE (3) MONTHS from the date on which the Services were performed, or (ii) THREE (3) MONTHS from the date on which the damage was discovered. Failure to comply with the above deadline will constitute an absolute bar to the pursuit of such a claim against the Society.

Article 6

6.1. These General Conditions shall be governed by and construed in accordance with United Arab Emirates (UAE) law, and any dispute arising from or in connection with the Rules or with the Services of the Society, including any issues concerning responsibility, liability or limitations of liability of the Society, shall be determined in accordance with UAE law. The courts of the Dubai International Financial Centre (DIFC) shall have exclusive jurisdiction in relation to any claim or dispute which may arise out of or in connection with the Rules or with the Services of the Society.

6.2. However,

- (i) In cases where neither the claim nor any counterclaim exceeds the sum of AED300,000 (Arab Emirates Dirhams Three Hundred Thousand) the dispute shall be referred to the jurisdiction of the DIFC Small Claims Tribunal; and
- (ii) for disputes concerning non-payment of the fees and/or expenses due to the Society for services, the Society shall have the

right to submit any claim to the jurisdiction of the Courts of the place where the registered or operating office of the Interested Party or of the applicant who requested the Service is located.

In the case of actions taken against the Society by a third party before a public Court, the Society shall also have the right to summon the Interested Party or the subject who requested the Service before that Court, in order to be relieved and held harmless according to art. 3.5 above.

Article 7

7.1. All plans, specifications, documents and information provided by, issued by, or made known to the Society, in connection with the performance of its Services, will be treated as confidential and will not be made available to any other party other than the Owner without authorisation of the Interested Party, except as provided for or required by any applicable international, European or domestic legislation, Charter or other IACS resolutions, or order from a competent authority. Information about the status and validity of class and statutory certificates, including transfers, changes, suspensions, withdrawals of class, recommendations/conditions of class, operating conditions or restrictions issued against classed ships and other related information, as may be required, may be published on the website or released by other means, without the prior consent of the Interested Party.

Information about the status and validity of other certificates and statements may also be published on the website or released by other means, without the prior consent of the Interested Party.

7.2. Notwithstanding the general duty of confidentiality owed by the Society to its clients in clause 7.1 above, the Society's clients hereby accept that the Society may participate in the IACS Early Warning System which requires each Classification Society to provide other involved Classification Societies with relevant technical information on serious hull structural and engineering systems failures, as defined in the IACS Early Warning System (but not including any drawings relating to the ship which may be the specific property of another party), to enable such useful information to be shared and used to facilitate the proper working of the IACS Early Warning System. The Society will provide its clients with written details of such information sent to the involved Classification Societies.

7.3. In the event of transfer of class, addition of a second class or withdrawal from a double/dual class, the Interested Party undertakes to provide or to permit the Society to provide the other Classification Society with all building plans and drawings, certificates, documents and information relevant to the classed unit, including its history file, as the other Classification Society may require for the purpose of classification in compliance with the applicable legislation and relative IACS Procedure. It is the Owner's duty to ensure that, whenever required, the consent of the builder is obtained with regard to the provision of plans and drawings to the new Society, either by way of appropriate stipulation in the building contract or by other agreement.

In the event that the ownership of the ship, product or system subject to certification is transferred to a new subject, the latter shall have the right to access all pertinent drawings, specifications, documents or information issued by the Society or which has come to the knowledge of the Society while carrying out its Services, even if related to a period prior to transfer of ownership.

Article 8

8.1. Should any part of these General Conditions be declared invalid, this will not affect the validity of the remaining provisions.

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1 GENERAL FIELD OF APPLICATION

These Rules apply for the purposes of issue and renewal of the "Type-Approval Certificate" for materials intended for the manufacture of single-skin and sandwich laminates for hulls.

These Rules do not concern the acceptance of materials for the purposes of structural fire protection, for which reference is made to the specific Tasneef requirements applicable to the various types of ship.

The following materials are considered in these Rules:

- laminating thermosetting resins and gel coats
- thermoplastic polymers glass fibres and relevant products
- aramid fibres and relevant products
- carbon-graphite fibres and relevant products
- core materials for sandwich laminates

Materials other than those listed above may be type-approved by Tasneef with the applicable procedures given in these Rules and on the basis of tests which will be stipulated in relation to the type of material for which type-approval is requested.

The following items describe procedures which are generally applicable irrespective of the the product to be type-approved.

Special requirements for the products listed here are provided in the individual Appendices

2 GENERAL REQUIREMENTS FOR MATERIALS

The requirements for each material are given in the Appendices relevant to the individual products. Requirements for materials other than those listed in 1, or for hybrid materials constituted by two different types of fibre, will be stipulated by Tasneef on the basis of equivalence criterion, taking into account the use of the proposed material and the type of reinforcement.

3 REQUEST FOR TYPE-APPROVAL

The manufacturer is to submit to Tasneef a request for type-approval together with the following information and associated documentation:

- location and description of the workshop;
- the identification characteristics of the product as shown, for each material, in the relevant appendices at the end of these Rules;
- technical report with a description of the production cycle;
- measurement and testing equipment available in the workshop;

- type of internal controls carried out during production.

4 WORKSHOP SURVEY

Subject to the satisfactory outcome of the examination of the documentation cited in item 3 above, Tasneef will perform a survey at the manufacturer's works in order to verify that:

- the workshop is provided with systems and equipment appropriate for the manufacture of the products;
- adequate quality control procedures of the production are implemented such as to ensure a constant quality level;
- the product possesses the general requirements listed in the relevant Appendices.

On the occasion of the workshop survey Tasneef also draws the sample for the type-approval tests, as indicated in the Appendices at the end of these Rules.

5 SAMPLING PROCEDURE

The selecting of material from which to draw samples for type-approval testing will be performed following Tasneef instructions at the manufacturer's warehouse or directly at the workshop.

For each product to be type-approved, sufficient samples are to be selected to provide the specimens necessary for the tests foreseen in the relevant Appendices; the preparation of test samples is to be carried out in the presence of a Tasneef Surveyor.

Prior to being subjected to testing, the specimens are to be conditioned as indicated for each product in the relevant Appendices at the end of these Rules.

6 TESTS

The specimens taken and conditioned as required in the relevant Appendices will be subjected to the tests specified therein.

Tests are generally to be performed in accordance with the procedures stipulated in the individual Standards shown in the Appendices.

Standards other than those given and issued by recognized national standards authorities may be considered by Tasneef in individual cases.

The tests will be carried out at a laboratory chosen in agreement with Tasneef subject to confirmation that such laboratory satisfies the provisions of ISO 17025 This condition may be considered satisfied if the laboratory is accredited or recognized by Tasneef in accordance with its " Rules for the recognition of test laboratories".

In special cases, where compliance with the above requirements is not demonstrated or the laboratory is not accredited, the tests may be performed provided that the Tasneef Surveyor is satisfied as regards:

- the suitability of the equipment for the type of test foreseen;
- the calibration of the instrumentation used for the tests, with traceability to national Standards;
- the availability of the Standards and test procedures.

Where carried out at the Interested Party's laboratory, tests are to be performed in the presence of Tasneef Surveyors.

In the case of testing at an independent laboratory, Tasneef reserves the right to participate in the preparation and performance of tests.

7 REQUIREMENTS

The requirements for the various materials are listed in the relevant Appendices.

8 EVALUATION OF TEST RESULTS

Unless otherwise shown in the individual Appendices, the values of the physical and/or mechanical characteristics to be considered vis-à-vis the values stipulated in these Rules or in the detailed list of the product are obtained by taking the arithmetic mean of a group of tests of the same type.

9 CERTIFICATION

Subject to the satisfactory outcome of the tests and checks given in the relevant Appendices, Tasneef will issue a Type-Approval Certificate showing, as well as the trade name of the product, the reference Standards adopted and the basic identification characteristics.

10 PERIOD OF VALIDITY OF TYPE-APPROVAL

The type-approval has three-year validity and may be renewed on expiry according to the procedure stipulated in item 12 and in the Appendices.

11 LOSS OF TYPE-APPROVAL

The type-approval issued by Tasneef lapses automatically if the manufacturer modifies the composition and/or the fabrication process of the product such that the characteristics of the latter are altered, without notifying Tasneef.

The type-approval may also lapse in the event of variations in the provisions according to which the Type-Approval Certificate was issued.

12 PROCEDURES AND TESTS FOR RENEWAL OF TYPE-APPROVAL

Prior to the expiry of the type-approval, generally three months in advance, the Interested Party may request renewal of the type-approval.

Where the fabrication process and materials used are unchanged with respect to the previous type-approval, such renewal will be issued subject to the satisfactory outcome of a new workshop survey and the repetition of the tests provided for in the relevant Appendices for each product.

In the event of alterations to the fabrication process and/or the use of materials other than those indicated at the previous type-approval, all or part of the tests foreseen in relation to such modifications will be repeated.

Subject to the satisfactory outcome of the checks above, a new Type-Approval Certificate will be issued.

Appendix 1 - Resins

A.1.1 GENERAL

The thermosetting resins considered in these Rules are laminating resins or gel coats of polyester type, polyester-vinylester epoxide type or phenolic.

Requirements for thermoplastic polymers are also included.

Resins of other types may be type-approved by ^{Tasneef} on request, on the basis of the tests and checks foreseen in these Rules and any supplementary tests and checks deemed necessary by ^{Tasneef} for the resin in question, such as to verify its suitability for hull construction with composite materials.

The resin is to wet the laminate fibres effectively and to provide adequate bonding in order to achieve laminates with suitable mechanical properties.

A.1.2 IDENTIFICATION CHARACTERISTICS

The following information, listed below by way of example and including where applicable reference to the test methods used, is to be submitted to ^{Tasneef} for each thermosetting resin:

- Type of resin (polyester, epoxide, etc.)
- Lay-up procedure (hand, mechanical etc.)
- Trade name
- Characteristics in the liquid state:
 - (a) density;
 - (b) viscosity;
 - (c) acid value (1);
 - (d) oxydrile number (1);
 - (e) styrene content (1)(7);
 - (f) monomer content (1), mineral content (2) (3) and volatile content (1) in per cent;
 - (g) type and quantity of catalyst and accelerator (if any);
 - (h) peak exothermic temperature in °C;
 - (i) gel time and setting time at ambient temperature of 20°C;
 - (j) linear and/or volumetric shrinkage, in per cent;
 - (k) epoxide content (component ratio);
 - (l) specific gravity;
 - (m) appearance;
 - (n) free phenol (4);
 - (o) free formaldehyde (4);
- Characteristics in the solid set state:
 - (a) density;
 - (b) water absorption;
 - (c) Barcol or Shore hardness (5);
 - (d) tensile modulus of elasticity;
 - (e) ultimate tensile strength (5);
 - (f) elongation strength;

- (g) deflection temperature (5);
- (h) abrasion resistance (5);
- (i) resistance to temperature variation (5);
- (j) resistance to atmospheric agents (5);
- (k) stress at break (6);
- (l) volume shrinkage after cure.

- Storage and maintenance conditions;
- Procedures for the use in relation to the manufacturing process of laminates;
- Stability in dark conditions, in months;
- Accelerator, fillers and colour pigments;
- Environmental conditions for the use (minimum and maximum temperatures for use and relative humidity).

Notes:

- (1) not Applicable for phenolic and epoxy;
- (2) total filler in the system;
- (3) for phenolic and epoxy the mineral content is required only in case of resin prefilled;
- (4) only for phenolic;
- (5) for laminating resin;
- (6) only for gel coat resins;
- (7) not required for epoxy.

The following information, listed below by way of example and including where applicable reference to the test methods used, is to be submitted to ^{Tasneef} for each thermoplastic polymers:

- a) melting point;
- b) melt flow index;
- c) density;
- d) filler content, if foreseen;
- e) pigment content, if foreseen;
- f) colour.

Curing and post curing defined by the Manufacturer have to be also indicated.

The above characteristics are generally to be determined using test methods in accordance with recognized standards such as: ASTM, ISO, etc. Any limitation on the application of the resin (e.g. "only for mechanical lay up" or "only to be used with glass fiber" , ...) to be reported on the Type Approval Certificate.

A.1.3 TESTS

For thermosetting resins cast samples are to be prepared in accordance with the manufacturer's recommendations and are to be cured and post-cured in a manner consistent with the intended use, curing and post curing are to be the same indicated by the Manufacturer and consistent with

Appendix 1 - Resins

the one reported in the User's Manual. The curing system used and the ratio of catalyst to resin are to be recorded.

For thermoplastic polymers samples for testing are to be prepared by moulding or extrusion under the polymer manufacturer's recommended conditions.

Resin samples are to be subjected to the following tests according to the procedures indicated:

- (a) Measurement of the density in the solid set state (g/cm^3).
3 resin specimens in the solid set state, prepared by curing and post curing as indicated by the Manufacturer (as an example curing done by gelation at an ambient temperature $> 18^\circ\text{C}$ for 24 hours and post-curing at a temperature of $40^\circ\text{C} \pm 2^\circ\text{C}$ for 16 hours).
- (b) Water absorption test (ASTM D 570 or ISO 62 Method 1).
The specimens are to have width of 50 mm and thickness in general of $3 \pm 0,2$ mm and to be cured and post cured as indicated by the Manufacturer. The resin is considered suitable when the absorption is < 60 mg after immersion in distilled water for 336 ± 2 hours.
- (c) Tensile elongation test (ASTM D 638, ISO 527-2 specimen 1A or 1B).
To be performed on type 1 specimens cured and post cured as indicated by the Manufacturer with speed of testing in general of $5 \text{ mm/min} \pm 20\%$ (reduced value but not less than $1 \text{ mm/min} \pm 20\%$ may be agreed with T_{asneef})

Number of specimens:

- 3 specimens (type 1)
- 3 specimens (type 1) immersed in sea water at ambient temperature for 24 hours;
- 3 specimens (type 1) immersed in gasoline at ambient temperature for 24 hours;
- 3 specimens (type 1) immersed in gas oil for motor vehicles at ambient temperature for 24 hours.

The ultimate tensile strength of the above specimens is to be $\geq 0,90 R_m$, R_m being the ultimate tensile strength of the material as supplied.

- (d) Heat temperature deflection Heat deflection temperature test under load (ISO 75 Method A).
The specimens are to be cured and post cured as indicated by the Manufacturer; the deflection temperature is to be greater than 60°C .

Number of specimens
- 3 specimens

- (e) Barcol or Shore hardness (ASTM D 2240)
The test to be on specimens cured and post cured as indicated by the Manufacturer.

Number of specimens
- 3 specimens

- (f) Ultimate Tensile strength and strain at maximum load (ISO 527-4 at speed = 5 mm/1' , specimen 1A or 1B or ASTM D 638) and flexural strength tests (ISO 178).
The above tests are to be performed on specimens drawn from a laminate manufactured with the resins to be type-approved according to the procedure indicated by the manufacturer. The laminate is to have a glass fibre content of approximately 30% (to be verified by testing) and to be manufactured with 4 mats of 450 g/m^2 (different type of reinforcement may be agreed with T_{asneef} Where the resin is recommended for certain types of fibres such as aramid or carbon fibres, the laminate is to be prepared with such fibres; in this case the composition will be stipulated each time by T_{asneef} The panel is to be cured and post cured as indicated by the Manufacturer prior to drawing the specimens to be subjected to the mechanical tests.

A1.4 EVALUATION OF TEST RESULTS

The minimum values for the above mentioned mechanical characteristics are reported in Table A.2.2 if glass or aramidic fiber are used for the specimens, Table A4.2.and A4.3 if carbon fiber are used as a function of G_c . The tensile strain to be at least 3% for gelcoat and 2,5 % for laminating resins.

Number of specimens
- 5 specimens

For gel coat to be determined also the modulus of elasticity in flexure.

Appendix 1 - Resins

Polymer samples are to be subjected to the following tests according to the procedures indicated.

For thermoplastic polymers the same test as per the thermosetting resins are to be performed and in addition the following test is to be carried out:

- ultimate and yield Compressive strength and modulus of elasticity in compression (ISO 604);
- the above tests are to be performed on specimens as in (c) The compressive strain to be at least 2.5%.

The test results are considered satisfactory if the arithmetic mean of the values obtained from the specimens is not less than the value required in the individual tests.

A1.5 RE-TESTS

Where the test results are unsatisfactory, at the request of the Interested Party a second round of tests may be performed on a second series of twice as many specimens as were tested initially.

A1.6 TESTS FOR RENEWAL OF TYPE-APPROVAL

Where the fabrication process and materials used are unchanged with respect to the previous type-approval, renewal will be issued subject to the satisfactory outcome of a new workshop survey and the repetition of the tests provided for in A1.3 (a), (c) and (d).

Appendix 2 - Glass fibres

A2.1 GENERAL

The Rules contained in this Appendix apply to the type-approval of E or S type glass fibre products. Glass reinforcements of other types (but with alkali content expressed in per cent of Na₂O < 1%) may be type-approved at the discretion of Tasneef on the basis of the tests given in this Appendix and any additional tests stipulated by Tasneef on the basis of the product submitted.

The glass fibre reinforcements foreseen generally consist of the following types of products:

- (continuous filament or chopped strand) mats,
- woven rovings,
- unidirectionals,
- combined products (for example mat and woven roving).

All products are intended for use in a laminating resin matrix according to the process stipulated by the manufacturer.

A2.2 IDENTIFICATION CHARACTERISTICS

In addition to that required in item 3 of the general section of these Rules, the following information, listed below by way of example and including where applicable reference to the test methods used, is to be submitted to Tasneef

- Trade name.
- Properties of the fibres:
 - (a) alkali content, in % of Na₂O;
 - (b) density, in g/cm³;
 - (c) diameter and length of fibres;
 - (d) type of dressing and bonding for fibre treatment.
- Characteristics of the product as supplied for the use (mat, woven roving, etc.) stating:
 - (a) linear mass or mass per area;
 - (b) moisture content;
 - (c) solubility in styrene;
 - (d) content of combustible materials;
 - (e) tensile strength;
 - (f) compatibility (e.g. suitable for polyesters, epoxides, etc.);
 - (g) fiber content
- Storage and maintenance conditions and procedure for use according to the manufacturing process of the laminates.

The chemical-physical characteristics above are to be determined according to recognized Standards such as for example ASTM, ISO, etc.

A2.3 PANEL SAMPLING PROCEDURE

The number of panels to be prepared for the selection of specimens will be stipulated for each

type of reinforcement in relation to the range of masses per area for which type-approval is requested.

As a rule, two panels are prepared, one using the minimum value and one using the maximum value of the mass per area in the range.

Where the range of masses per area for which type-approval is requested is very wide, generally greater than four masses per area, a third panel is to be prepared using reinforcements with an intermediate mass per area.

The panels are to be manufactured preferably using the hand lay-up or special lay-up process foreseen for the use and to be subjected to the curing and post curing indicated by the Manufacturer.

An approved resin of suitable type is to be used. The type of resin (epoxy, vinilester etc) is to be declared and it will be indicated on the certificate.

A minimum of three layers of the reinforcement is to be laid with parallel ply to give a laminate having a thickness between 3 and 4 mm.

The glass/resin ratios, by weight to be used is shown in Table A2.1

Table A2.1 Glass content by weight for different reinforcement types

Reinforcement type	Glass content
Unidirectional	0,60
Chopped strand mat	0,30
Woven roving, cloth	0,50
Continuous fibre with chopped strand mat	0,45
+, - 45°/Triaxial/quadriaxial stitched parallel plied roving	0,50

A2.4 NUMBER AND DIRECTION OF SPECIMENS TO BE SELECTED

The number of specimens to be selected from each panel prepared as stated in A2.3 and subjected to the tests in A2.5 is to be as shown below:

- (a) Mats, woven rovings, cloths (unconditioned)
 - 10 specimens for tensile tests, 5 of which in the 0° (warp yarn or longitudinal) direction indicated by **L**; and 5 in the 90° (weft yarn or transverse) direction indicated by **T**;
 - 10 specimens for flexural tests, 5 of which **L** and 5 **T**;
 - 6 specimens for compressive tests, 3 of which **L** and 3 **T**;

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- 6 specimens for shear tests, 3 of which **L** and 3 **T**;
- 6 specimens for interlaminar shear tests, 3 of which **L** and 3 **T**.

Mats, woven rovings, cloths (conditioned)

- 10 specimens for tensile tests, 5 of which in the 0° (warp yarn or longitudinal) direction indicated by **L**; and 5 in the 90° (weft yarn or transverse) direction indicated by **T**;
- 10 specimens for flexural tests, 5 of which **L** and 5 **T**;
- 6 specimens for compressive tests, 3 of which **L** and 3 **T**;
- 6 specimens for shear tests, 3 of which **L** and 3 **T**;
- 6 specimens for interlaminar shear tests, 3 of which **L** and 3 **T**.

(b) Unidirectionals (unconditioned)

- 5 specimens in the direction of the reinforcement for tensile tests;
- 5 specimens in the direction of the reinforcement for compressive tests;
- 5 specimens in the direction of the reinforcement for flexural tests;
- 3 specimens in the direction of the reinforcement for interlaminar shear tests.
- 5 specimens 90° from the direction of the reinforcement for tensile tests;
- 5 specimens 90° from the direction of the reinforcement for compressive tests;
- 5 specimens 90° from the direction of the reinforcement for flexural tests;
- 3 specimens 90° from the direction of the reinforcement for interlaminar shear tests.

Unidirectionals (conditioned)

- 5 specimens in the direction of the reinforcement for tensile tests;
- 5 specimens in the direction of the reinforcement for compressive tests;
- 5 specimens in the direction of the reinforcement for flexural tests;
- 3 specimens in the direction of the reinforcement for interlaminar shear tests.
- 5 specimens 90° from the direction of the reinforcement for tensile tests;

- 5 specimens 90° from the direction of the reinforcement for compressive tests;
- 5 specimens 90° from the direction of the reinforcement for flexural tests;
- 3 specimens 90° from the direction of the reinforcement for interlaminar shear tests.

(c) chopped strand mat (unconditioned)

- 5 specimens in any direction of the reinforcement for tensile tests;
- 5 specimens in the direction of the reinforcement for compressive tests;
- 5 specimens in any direction of the reinforcement for flexural tests;
- 3 specimens in any direction of the reinforcement for shear tests.
- 3 specimens in any direction of the reinforcement for interlaminar shear tests.

chopped strand mat (conditioned)

- 5 specimens in any direction of the reinforcement for tensile tests;
- 5 specimens in the direction of the reinforcement for compressive tests;
- 5 specimens in any direction of the reinforcement for flexural tests;
- 3 specimens in any direction of the reinforcement for shear tests.
- 3 specimens in any direction of the reinforcement for interlaminar shear tests.

(d) Triaxial/Quadriaxial (unconditioned)

- 20 specimens for tensile tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction
- 20 specimens for compressive tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction
- 20 specimens for flexural tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction

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- the -45° direction;
- 12 specimens for shear tests, 3 of which in the 0° (warp yarn or longitudinal) direction; 3 in the 90° (weft yarn or transverse) direction, 3 of which in the +45° direction; and 3 in the -45° direction;
- 12 specimens for interlaminar shear tests, 3 of which in the 0° (warp yarn or longitudinal) direction; 3 in the 90° (weft yarn or transverse) direction, 3 of which in the +45° direction; and 3 in the -45° direction;

Triaxial/Quadriaxial (conditioned)

- 20 specimens for tensile tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction
- 20 specimens for compressive tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction
- 20 specimens for flexural tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction;
- 12 specimens for shear tests, 3 of which in the 0° (warp yarn or longitudinal) direction; 3 in the 90° (weft yarn or transverse) direction, 3 of which in the +45° direction; and 3 in the -45° direction;
- 12 specimens for interlaminar shear tests, , 3 of which in the 0° (warp yarn or longitudinal) direction; 3 in the 90° (weft yarn or transverse) direction, 3 of which in the +45° direction; and 3 in the -45° direction;

The above number of specimens may be reduced or increased upon positive/negative results of the mechanical tests.

A2.5 MEASUREMENTS AND TESTS

A2.5.1 MEASUREMENTS

The following measurements are to be performed:

- (a) mass per area of the base product supplied, in g/m², by weighing 3 samples.
- (b) total mass per area **Q**, in g/m², of each panel in A2.3 and determination of the glass content **G_c** given by **P/Q**, **P** being the total mass per area, in g/m², of fibres in the panel. The specimens of the largest size according to the instruments available are to be at least 3 taken in different zones of the panel, ^{Tasneef} reserves the right of ask additional specimens if considered necessary. As an alternative ISO 1172 may be used.

A2.5.2 TESTS

The specimens in A2.4 are to be subjected to the tests indicated below.

These tests are generally to be performed in accordance with the following Standards or with other recognized Standards previously agreed upon with ^{Tasneef}

- (a) tensile strain, strength and modulus (ASTM D 638 or ISO 527-4 speed = 2 mm/1' specimen Type II or III)
Tensile tests are to be performed on unconditioned specimens and after immersion in fresh water at a temperature of 50°C ± 5 for 25 days.
- (b) Compressive strength and modulus (ASTM D 695 or ISO 604 speed =1mm/1').
- (c) flexural strength and modulus (ASTM D 790 or ISO 14125 speed = t/2 mm/1' Method A). Flexural tests are to be performed on unconditioned specimens and after immersion in fresh water at a temperature of 50°C ± 5 for 25 days.
- (d) shear strength and modulus (ASTM D 732)
- (e) interlaminar shear strength (ASTM D 3846 or ISO 14130).

The tests other than tensile and flexural tests may be carried out on unconditioned specimens only, unless ^{Tasneef} - after comparison between the results of unconditioned and conditioned tensile and flexural tests - deems it necessary to also test conditioned specimens.

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A2.6 EVALUATION OF TEST RESULTS

(a) Tensile tests

The values of the tensile modulus of elasticity E_i and the ultimate tensile strength R_{mi} of each specimen are to be determined by means of the corresponding stresses-strains diagram.

The arithmetic mean of the values obtained from the five **L** and five **T** specimens is then determined.

The difference between the two mean values is generally not to be greater than 20%.

The mean of the two values gives the value of the modulus of elasticity E and the ultimate tensile strength R_m of the laminate.

The above values are to be not less than those obtained, as a function of G_c , from Table A2.2.

The value found for each specimen of the group is to be not less than 90% of the value shown in the above Table.

For unidirectional reinforcements the mean value of the five specimens is to be taken.

(a) Compressive

The values of the modulus of elasticity E_{ci} and the ultimate compressive strength R_{mci} are to be determined by means of the relevant stresses-strains diagram.

The mean values E_c and R_{mc} are then determined as stated in (a) and are to be not less than those supplied by the manufacturer and, in any case, not less than the values obtained from the formulas

in Table A2.2.

(c) Flexural tests

The values of the modulus of elasticity E_{fi} and the ultimate flexural strength R_{mfi} of each of the ten specimens are to be determined by means of the relevant stresses/strains diagram.

The mean values are then determined as stipulated in (a).

The mean values of E_f and R_{mf} are to be not less than the values given in Table A5.2 or A5.3 or A5.4 as applicable in Appendix 5 as a function of G_c .

The value found for each specimen is to be not less than 90% of the value shown in the above Table.

(d) Shear tests

The mean value, determined as stated in (a), of the ultimate shear strength is to be not less than the value given in Table A2.2.

The value given by each specimen is to be not less than 90% of the value shown in the above Table.

(e) Interlaminar shear tests

The interlaminar shear strength obtained by determining the arithmetic mean of the results of the individual specimens as stated in (a) is to be not less than the value given by the formulas in Table A2.2.

The value given by each specimen is to be not less than 90% of the value shown in the above Table.

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Table A2.2

Unidirectional Values in N/mm ²		
R_{m0} ultimate tensile strength= $1278 G_c^2 - 510 G_c + 123$		
R_{m 90}	= ultimate tensile strength	= $44 G_c^2 - 28 G_c + 8.5$
E0	= tensile modulus of elasticity	= $(37 G_c - 4,75) 10^3$
E 90	= tensile modulus of elasticity	= $1685 * G_c^2 - 395 * G_c + 630$
R_{mc0}	= ultimate compressive strength	= $150 G_c + 72$
R_{mc90}	= ultimate compressive strength	= $286 * G_c^2 - 12 * G_c + 71$
E_c	= compressive modulus of elasticity	= $(40 G_c - 6) 10^3$
R_{mf}	= ultimate flexural strength	= $(502 G_c^2 + 107)$
E_f	= flexural modulus of elasticity	= $(33,4 G_c^2 + 2,2) 10^3$
R_{mt}	= ultimate shear strength	= $80 G_c + 38$
G	= shear modulus of elasticity	= $(1,7 G_c + 2,24) 10^3$
R_{mti}	= ultimate interlaminar shear strength	= $22,5 - 17,5 G_c$
For other type of lamination		
R_m ultimate tensile strength= $1278 G_c^2 - 510 G_c + 123$		
E	= tensile modulus of elasticity	= $(37 G_c - 4,75) 10^3$
R_{mc}	= ultimate compressive strength	= $150 G_c + 72$
E_c	= compressive modulus of elasticity	= $(40 G_c - 6) 10^3$
R_{mf}	= ultimate flexural strength	= $(502 G_c^2 + 107)$
E_f	= flexural modulus of elasticity	= $(33,4 G_c^2 + 2,2) 10^3$
R_{mt}	= ultimate shear strength	= $80 G_c + 38$
G	= shear modulus of elasticity	= $(1,7 G_c + 2,24) 10^3$
R_{mti}	= ultimate interlaminar shear strength	= $22,5 - 17,5 G_c$
<i>Values in N/mm²</i>		

Appendix 2 - Glass fibres

A2.7 RE-TESTS

Where the value obtained from one of the specimens is less than 90% of the value given in Table A2.2, or the mean result does not exceed the values in the Table, the test results are generally considered unsatisfactory.

In such case further specimens are to be selected, equal in number to the original and from the same panel, and re-tested.

The values obtained from these tests are to be added to those obtained previously in order to determine the arithmetic mean as stated in A2.6 (a), and such mean is to be not less than the value shown in the Table above.

Where the value found in this second group of specimens is less than that in Table A2.2, or the overall mean of the test results is less than the value shown in the Table, the final outcome is to be considered unsatisfactory and a new panel is to be fabricated.

A2.8 TESTS FOR RENEWAL OF TYPE-APPROVAL

Where the fabrication process and materials used are unchanged with respect to the previous type-approval, renewal will be issued subject to the satisfactory outcome of a new workshop survey and the repetition of the tests provided for in A2.5.2 (a) and (b).

Appendix 3 - Aramid fibres

A3.1 GENERAL

The Rules contained in this Appendix apply to the type-approval of aramid fibre products such as for example Kevlar 49 Aramid (trade mark of Du Pont de Nemours) used to fabricate products such as woven rovings or cloths.

The type-approval presupposes that products are used according to the manufacturing process recommended by the manufacturer such that laminates have values of the mechanical properties not less than those supplied by the manufacturer and, in any case, not less than the values obtained from the formulas in Table A2.2 in Appendix 2 assuming for G_c the value K_c of the laminate.

A3.2 IDENTIFICATION CHARACTERISTICS

In addition to that required in item 3 of the general section of these Rules, the following further information, listed below by way of example and including where applicable reference to the test methods used, is to be submitted to ^{Tasneef}

- Trade name
- Properties of the fibres, in strands
 - (a) diameter, in mm;
 - (b) deniers, in g/1000 m;
 - (c) density, in g/cm³;
 - (d) tensile modulus of elasticity, in N/mm² (which is generally to be between 115000 and 120000 N/mm²);
 - (e) ultimate tensile strength, in N/mm², and relevant elongation, in per cent;
 - (f) resistance to temperature;
 - (g) surface protective coating.
- Characteristics of the product as supplied for the use (mat, woven roving, etc.) stating:
 - (a) mass per area, in g/m²;
 - (b) linear mass, in g/m, in the case of unidirectionals;
 - (c) thickness, in mm;
 - (d) moisture content, in mm;
 - (e) type of dressing and bonding for fiber treatment;
 - (f) content of combustible material;
 - (g) compatibility (e.g. suitable for polyesters, epoxides, etc.);
 - (h) fiber content.

Storage and maintenance conditions and procedure for use depending on the type of resin of the matrix and the manufacturing process of the laminates.

The physical characteristics above are to be determined according to recognized Standards such as for example ASTM, ISO, etc.

A3.3 PANEL SAMPLING PROCEDURE

The number of panels to be prepared for the selection of specimens will be stipulated for each type of reinforcement in relation to the range of masses per area for which type-approval is requested.

As a rule, two panels are prepared, one using the minimum value and one using the maximum value of the mass per area in the range.

Where the range of masses per area for which type-approval is requested is very wide, generally greater than four masses per area, a third panel is to be prepared using reinforcements with an intermediate mass per area.

The panels are to be manufactured using the resin recommended by the manufacturer, the process foreseen for the normal production and reinforcements of aramid fibres only.

An approved resin of suitable type is to be used.

A minimum of three layers of the reinforcement is to be laid with parallel ply to give a laminate having a thickness between 3 and 4 mm.

The glass/resin ratios, by weight to be used is shown in Table A3.1

Table A3.1 content by volume for reinforcement different from glass

Reinforcement type	Content by volume (1)
Unidirectional	0,41
Chopped strand mat	0,17
Woven roving, cloth	0,32
+,- 45°/Triaxial/quadraxial stitched parallel plied roving	0,32
(1) The weight fraction can be calculated by the formula: $W_f = V_f \cdot D_f(D_f \cdot V_f + D_r \cdot V_r)$ where: W_f : fibre fraction by weight D_f : density of fibre D_r : density of resin V_f : fibre fraction by volume V_r : resin fraction by volume.	

In addition, an equal number of panels are to be manufactured having promiscuous reinforcements, i.e. glass reinforcements (generally in the form of mats) and aramid fibre reinforcements, laid in alternate layers and such that the glass content G_c is approximately equal to the aramid fibre content K_c .

The total reinforcement content is to be between 0,45 and 0,50.

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A3.4 NUMBER AND DIRECTION OF SPECIMENS TO BE SELECTED

The number of specimens to be selected from each panel in A3.3 and prepared for the tests in A3.5 is to be as shown below:

- (a) Mats, woven rovings, cloths (unconditioned)
- 10 specimens for tensile tests, 5 of which in the 0° (warp yarn or longitudinal) direction indicated by **L**; and 5 in the 90° (weft yarn or transverse) direction indicated by **T**;
 - 10 specimens for flexural tests, 5 of which **L** and 5 **T**;
 - 6 specimens for compressive tests, 3 of which **L** and 3 **T**;
 - 6 specimens for shear tests, 3 of which **L** and 3 **T**;
 - 6 specimens for interlaminar shear tests, 3 of which **L** and 3 **T**.

- Mats, woven rovings, cloths (conditioned)
- 10 specimens for tensile tests, 5 of which in the 0° (warp yarn or longitudinal) direction indicated by **L**; and 5 in the 90° (weft yarn or transverse) direction indicated by **T**;
 - 10 specimens for flexural tests, 5 of which **L** and 5 **T**;
 - 6 specimens for compressive tests, 3 of which **L** and 3 **T**;
 - 6 specimens for shear tests, 3 of which **L** and 3 **T**;
 - 6 specimens for interlaminar shear tests, 3 of which **L** and 3 **T**.

- (b) Unidirectionals (unconditioned)
- 5 specimens in the direction of the reinforcement for tensile tests;
 - 5 specimens in the direction of the reinforcement for compressive tests;
 - 5 specimens in the direction of the reinforcement for flexural tests;
 - 3 specimens in the direction of the reinforcement for interlaminar shear tests.
 - 5 specimens 90° from the direction of the reinforcement for tensile tests;
 - 5 specimens 90° from the direction of the reinforcement for compressive tests;
 - 5 specimens 90° from the direction of the reinforcement for flexural tests;

- 3 specimens 90° from the direction of the reinforcement for interlaminar shear tests.

Unidirectionals (conditioned)

- 5 specimens in the direction of the reinforcement for tensile tests;
- 5 specimens in the direction of the reinforcement for compressive tests;
- 5 specimens in the direction of the reinforcement for flexural tests;
- 3 specimens in the direction of the reinforcement for interlaminar shear tests.
- 5 specimens 90° from the direction of the reinforcement for tensile tests;
- 5 specimens 90° from the direction of the reinforcement for compressive tests;
- 5 specimens 90° from the direction of the reinforcement for flexural tests;
- 3 specimens 90° from the direction of the reinforcement for interlaminar shear tests.

(c) chopped strand mat (unconditioned)

- 5 specimens in any direction of the reinforcement for tensile tests;
- 5 specimens in the direction of the reinforcement for compressive tests;
- 5 specimens in any direction of the reinforcement for flexural tests;
- 3 specimens in any direction of the reinforcement for shear tests.
- 3 specimens in any direction of the reinforcement for interlaminar shear tests.

chopped strand mat (conditioned)

- 5 specimens in any direction of the reinforcement for tensile tests;
- 5 specimens in the direction of the reinforcement for compressive tests;
- 5 specimens in any direction of the reinforcement for flexural tests;
- 3 specimens in any direction of the reinforcement for shear tests.
- 3 specimens in any direction of the reinforcement for interlaminar shear tests.

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(d) Triaxial/Quadriaxial (unconditioned)

- 20 specimens for tensile tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction
- 20 specimens for compressive tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction
- 20 specimens for flexural tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction;
- 12 specimens for shear tests, 3 of which in the 0° (warp yarn or longitudinal) direction; 3 in the 90° (weft yarn or transverse) direction, 3 of which in the +45° direction; and 3 in the -45° direction;
- 12 specimens for interlaminar shear tests, , 3 of which in the 0° (warp yarn or longitudinal) direction; 3 in the 90° (weft yarn or transverse) direction, 3 of which in the +45° direction; and 3 in the -45° direction;

Triaxial/Quadriaxial (conditioned)

- 20 specimens for tensile tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction
- 20 specimens for compressive tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction
- 20 specimens for flexural tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction;
- 12 specimens for shear tests, 3 of which in the 0° (warp yarn or longitudinal) direction; 3 in the 90°

(weft yarn or transverse) direction, 3 of which in the +45° direction; and 3 in the -45° direction;

- 12 specimens for interlaminar shear tests, , 3 of which in the 0° (warp yarn or longitudinal) direction; 3 in the 90° (weft yarn or transverse) direction, 3 of which in the +45° direction; and 3 in the -45° direction;

The above number of specimens may be reduced or increased upon positive/negative results of the mechanical tests.

A3.5 MEASUREMENTS AND TESTS

A3.5.1 MEASUREMENTS

The following measurements are to be performed:

- (a) mass per area of the product, in g/m², , by weighing 3 samples;
- (b) total mass per area **Q**, in g/m², of each panel in A3.3 and determination of the reinforcement content **K_c** given by **P/Q**, **P** being the total mass per area, in g/m², of aramid fibres in the panel. The specimens of the largest size according to the instruments available are to be at least 3 taken in different zones of the panel, ^{Tasneef} reserves the right of ask additional specimens if considered necessary. As an alternative ISO 1172 may be used.

A3.5.2 TESTS

The specimens in A3.4 are to be subjected to the tests indicated below; these tests are generally to be performed in accordance with the following Standards and, in any case, with recognized Standards:

- (a) Tensile strain, strength and modulus (ASTM D 638 or ISO 527-4 speed = 2 mm/1' specimen Type II or III)
Tensile tests are to be performed on unconditioned specimens and after immersion in fresh water at a temperature of 50°C ± 5 for 25 days.
- (b) Compressive strength and modulus (ASTM D 695 or ISO 604 speed =1mm/1').
- (c) Flexural strength and modulus (ASTM D 790 or ISO 14125 speed = t/2 mm/1' Method A). Flexural tests are to be performed on unconditioned specimens and after immersion in fresh water at a temperature of 50°C ± 5 for 25 days.

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- (d) Shear strength and modulus (ASTM D 732).
- (e) Interlaminar shear strength (ASTM D 3846 or ISO 14130).

The tests other than tensile and flexural tests may be carried out on unconditioned specimens only, unless ^{Tasneef} - after comparison between the results of unconditioned and conditioned tensile and flexural tests - deems it necessary to also test conditioned specimens.

A3.6 EVALUATION OF TEST RESULTS

- (a) Tensile tests

The values of the tensile modulus of elasticity E_t and the ultimate tensile strength R_{mt} of each specimen are to be determined by means of the corresponding stresses-strains diagram.

The arithmetic mean of the values obtained from the five **L** and five **T** specimens is then determined.

The difference between the two mean values is generally not to be greater than 20%.

The mean of the two values gives the value of the modulus of elasticity E_t and the ultimate tensile strength R_m of the material.

The above values are to be not less than those supplied by the manufacturer and, in any case, not less than the values obtained from the formulas in Table A2.2 in Appendix 2 assuming for G_c the value K_c of the laminate.

For unidirectional reinforcements the mean value of the five specimens is to be taken.

The values for the specimens after immersion in water are to be not less than 90% of the values obtained from the unconditioned specimens.

- (b) Compressive tests

The values of the modulus of elasticity E_{ci} and the ultimate compressive strength R_{mci} are to be determined by means of the relevant stresses-strains diagram.

The mean values E_c and R_{mc} are then determined as stated in (a), and are to be not less than those supplied by the manufacturer and, in any case, not less than the values obtained from the formulas

in Table A2.2 in Appendix 2 assuming for G_c the value K_c of the laminate.

- (c) Flexural tests

The values of the modulus of elasticity E_f and the ultimate flexural strength R_{mfi} of each of the ten specimens are to be determined by means of the relevant stresses/strains diagram. The mean values are then determined as stipulated in (a).

The mean values of E_f and R_{mf} are to be not less than the values supplied by the manufacturer and, in any case, not less than the values obtained from the formulas in Table A2.2 in Appendix 2 assuming for G_c the value K_c of the laminate.

- (d) Shear tests

The mean value, determined as stated in (a), of the ultimate shear strength is to be not less than the value recommended by the manufacturer and, in any case, not less than the value in Table A2.2 in Appendix 2 assuming for G_c the value K_c of the laminate.

- (e) Interlaminar shear tests

The interlaminar shear strength obtained by determining the mean of the results of the individual specimens as stated in (a) is to be not less than the value recommended by the manufacturer and, in any case, not less than the value in Table A2.2 in Appendix 2 assuming for G_c the value K_c of the laminate.

A3.7 RE-TESTS

Where the mean result is less than the value supplied by the manufacturer or, in general, where the value obtained from one of the specimens is less than the value given in Table A2.2 in Appendix 2, the test results are considered unsatisfactory.

In such case further specimens are to be selected, equal in number to the original and from the same panel, and re-tested.

Where the value found in this second group of specimens is less than that supplied by the manufacturer or that in Table A2.2 in Appendix 2, the final outcome is to be considered

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unsatisfactory and a new panel is to be fabricated. The values obtained from these tests are to be added to those obtained previously in order to determine the arithmetic mean as stated in A3.6 (a) and such mean is to be not less than the values recommended by the manufacturer or those shown in Table A2.2 in Appendix 2.

A3.8 TESTS FOR RENEWAL OF TYPE-APPROVAL

Where the fabrication process and materials used are unchanged with respect to the previous type-approval, renewal will be issued subject to the satisfactory outcome of a new workshop survey and the repetition of the tests provided for in A3.5.2 (a) on unconditioned specimens and (e).

Appendix 4 - Carbon graphite fibres

A4.1 GENERAL

The Rules contained in this Appendix apply to the type-approval of products in Carbon-Graphite usually called "carbon", which are used in the form of materials suitable to be incorporated as reinforcements in the laminating resin matrix for the construction of structural parts.

The type-approval presupposes that products are used according to the manufacturing process recommended by the manufacturer such that laminates have values of the mechanical properties not less than those supplied by the manufacturer and, in any case, not less than the values obtained from the formulas in Table A4.2 or A4.3 as applicable assuming for G_c the value C_c of the laminate.

A4.2 IDENTIFICATION CHARACTERISTICS

In addition to that required in Article 3 of the general section of these Rules, the following further information, listed below by way of example and including where applicable reference to the test methods used, is to be submitted to Tasneef

- Trade name
- Properties of the fibres, in strands
 - (a) diameter, in mm;
 - (b) deniers, in g/1000 m;
 - (c) density, in g/cm³ (generally between 1,7 and 1,9 g/ cm³);
 - (d) tensile modulus of elasticity, in N/mm² (which is generally to be between 400000 and 200000 N/mm²);
 - (e) ultimate tensile strength, in N/mm², (generally between 1700 and 2500 N/mm²) and relevant elongation, in per cent, generally between about 0,4 and 1;
 - (f) surface treatment, in particular against oxidation.
- Characteristics of the product as supplied for the use (woven roving, unidirectional, etc.) stating:
 - (a) mass per area, in g/m²;
 - (b) linear mass, in g/m, in the case of unidirectionals;
 - (c) thickness, in mm;
 - (d) moisture content, in mm;
 - (e) diameter and Length of fibres;
 - (f) type of dressing and bonding for fiber treatment;

- (g) content of combustible material;
- (h) compatibility (e.g. suitable for polyesters, epoxides, etc.);
- (i) fiber content.

- Storage and maintenance conditions and procedure for use depending on the type of resin of the matrix and the manufacturing process of the laminates.

The physical characteristics above are to be determined according to recognized Standards such as for example ASTM, ISO, etc.

A4.3 PANEL SAMPLING PROCEDURE

The number of panels to be prepared for the selection of specimens will be stipulated for each type of reinforcement in relation to the range of masses per area for which type-approval is requested, the manufacturing process and the conditions for use.

As a rule, two panels are prepared, one using the minimum value and one using the maximum value of the mass per area in the range.

Where the range of masses per area for which type-approval is requested is very wide, generally greater than four masses per area, a third panel is to be prepared using reinforcements with an intermediate mass per area.

The panels are to be manufactured using the resin recommended by the manufacturer and the process foreseen for the normal production.

An approved resin of suitable type is to be used. A minimum of three layers of the reinforcement is to be laid with parallel ply to give a laminate having a thickness between 3 and 4 mm.

The glass/resin ratios, by weight to be used is shown in Table A4.1

Table A 4.1 content by volume for reinforcement different from glass

Reinforcement type	Content by volume (1)
Unidirectional	0,41
Chopped strand mat	0,17
Woven roving, cloth	0,32
+,- 45°/Triaxial/quadriaxial stitched parallel plied roving	0,32
<p>(1) The weight fraction can be calculated by the formula: $W_f = V_f \cdot D_f(D_f \cdot V_f + D_r \cdot V_r)$ where: W_f : fibre fraction by weight D_f : density of fibre D_r : density of resin V_f : fibre fraction by volume V_r : resin fraction by volume.</p>	

Appendix 4 - Carbon graphite fibres

The product is to be cured and kept at an ambient temperature $\geq 18^{\circ}\text{C}$ for 24 hours, then subjected to post-curing at a temperature of $40^{\circ}\text{C} \pm 2$ for 16 hours.

The composition is to be such that the laminate may be considered "nearly isotropous". In the case of unidirectional products the composition is to be of unidirectional type.

A4.4 NUMBER AND DIRECTION OF SPECIMENS TO BE SELECTED

The number of specimens to be selected from each panel in A4.3 and prepared for the tests in A4.5.2 is to be as shown below:

(a) Mats, woven rovings, cloths (unconditioned)

- 10 specimens for tensile tests, 5 of which in the 0° (warp yarn or longitudinal) direction indicated by **L**; and 5 in the 90° (weft yarn or transverse) direction indicated by **T**;
- 10 specimens for flexural tests, 5 of which **L** and 5 **T**;
- 6 specimens for compressive tests, 3 of which **L** and 3 **T**;
- 6 specimens for interlaminar shear tests, 3 of which **L** and 3 **T**.

Mats, woven rovings, cloths (conditioned)

- 10 specimens for tensile tests, 5 of which in the 0° (warp yarn or longitudinal) direction indicated by **L**; and 5 in the 90° (weft yarn or transverse) direction indicated by **T**;
- 10 specimens for flexural tests, 5 of which **L** and 5 **T**;
- 6 specimens for compressive tests, 3 of which **L** and 3 **T**;
- 6 specimens for interlaminar shear tests, 3 of which **L** and 3 **T**.

(b) Unidirectionals (unconditioned)

- 5 specimens in the direction of the reinforcement for tensile tests;
- 5 specimens in the direction of the reinforcement for compressive tests;
- 5 specimens in the direction of the reinforcement for flexural tests;
- 3 specimens in the direction of the reinforcement for interlaminar shear tests.
- 5 specimens 90° from the direction of

- the reinforcement for tensile tests;
- 5 specimens 90° from the direction of the reinforcement for compressive tests;
- 5 specimens 90° from the direction of the reinforcement for flexural tests;
- 3 specimens 90° from the direction of the reinforcement for interlaminar shear tests.

Unidirectionals (conditioned)

- 5 specimens in the direction of the reinforcement for tensile tests;
- 5 specimens in the direction of the reinforcement for compressive tests;
- 5 specimens in the direction of the reinforcement for flexural tests;
- 3 specimens in the direction of the reinforcement for interlaminar shear tests.
- 5 specimens 90° from the direction of the reinforcement for tensile tests;
- 5 specimens 90° from the direction of the reinforcement for compressive tests;
- 5 specimens 90° from the direction of the reinforcement for flexural tests;
- 3 specimens 90° from the direction of the reinforcement for interlaminar shear tests.

(c) chopped strand mat (unconditioned)

- 5 specimens in any direction of the reinforcement for tensile tests;
- 5 specimens in the direction of the reinforcement for compressive tests;
- 5 specimens in any direction of the reinforcement for flexural tests;
- 3 specimens in any direction of the reinforcement for interlaminar shear tests.

chopped strand mat (conditioned)

- 5 specimens in any direction of the reinforcement for tensile tests;
- 5 specimens in the direction of the reinforcement for compressive tests;
- 5 specimens in any direction of the reinforcement for flexural tests;
- 3 specimens in any direction of the reinforcement for interlaminar shear tests.

Appendix 4 - Carbon graphite fibres

(d) Triaxial/Quadriaxial (unconditioned)

- 20 specimens for tensile tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction
- 20 specimens for compressive tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction
- 20 specimens for flexural tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction;
- 12 specimens for interlaminar shear tests, , 3 of which in the 0° (warp yarn or longitudinal) direction; 3 in the 90° (weft yarn or transverse) direction, 3 of which in the +45° direction; and 3 in the -45° direction;

Triaxial/Quadriaxial (conditioned)

- 20 specimens for tensile tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction
- 20 specimens for compressive tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction
- 20 specimens for flexural tests, 5 of which in the 0° (warp yarn or longitudinal) direction; 5 in the 90° (weft yarn or transverse) direction, 5 of which in the +45° direction, and 5 in the -45° direction;
- 12 specimens for interlaminar shear tests, , 3 of which in the 0° (warp yarn or longitudinal) direction; 3 in the 90° (weft yarn or transverse) direction, 3 of which in the +45° direction; and 3 in the -45° direction;

The above number of specimens may be reduced or increased upon positive/negative results of the mechanical tests.

A4.5 MEASUREMENTS AND TESTS

A4.5.1 MEASUREMENTS

The following measurements are to be performed:
 (a) mass per area of the product, in g/m^2 , by weighing 3 samples;
 (b) total mass per area **Q**, in g/m^2 , of each panel in A4.3 and determination of the reinforcement content **C_c** given by **P/Q**, **P** being the total mass per area, in g/m^2 , of carbon fibres in the panel. The specimens of the largest size according to the instruments available are to be at least 3 taken in different zones of the panel, ^{Tasneef} reserves the right of ask additional specimens if considered necessary. As an alternative ISO 1172 may be used.

A4.5.2 TESTS

The specimens in A4.4 are to be subjected to the tests indicated below; these tests are generally to be performed in accordance with the following Standards and, in any case, with recognized Standards:

- (a) tensile strain, strength and modulus (ASTM D 638 or ISO 527-4 speed = 2 mm/1' specimen Type II or III)
Tensile tests are to be performed on unconditioned specimens and after immersion in fresh water at a temperature of 50°C±/2 for 25 days.
- (b) Compressive strength and modulus (ASTM D 695 or ISO 604 speed =1mm/1')
- (c) Flexural strength and modulus (ASTM D 790 or ISO 14125 speed = t/2 mm/1' Method A). Flexural tests are to be performed on unconditioned specimens and after immersion in fresh water at a temperature of 50°C ± 5 for 25 days.
- (d) Interlaminar shear strength (ASTM D 3846 or ISO 14130).

The tests other than tensile and flexural tests may be carried out on unconditioned specimens only, unless ^{Tasneef} - after comparison between the results of unconditioned and conditioned tensile and flexural tests - deems it necessary to also test conditioned specimens.

Appendix 4 - Carbon graphite fibres

A4.6 EVALUATION OF TEST RESULTS

(a) Tensile tests

The values of the tensile modulus of elasticity E_i and the ultimate tensile strength R_{mi} of each specimen are to be determined by means of the corresponding stresses-strains diagram.

The arithmetic mean of the values obtained from the five **L** and five **T** specimens is then determined. The difference between the two mean values is generally not to be greater than 20%.

The mean of the two values gives the value of the modulus of elasticity **E** and the ultimate tensile strength R_m of the material.

The above values are to be not less than those supplied by the manufacturer and, in any case, not less than the values obtained from the formulas in Table A4.2 or A4.3 as applicable 5.

For unidirectional reinforcements the mean value of the five specimens is to be taken. The values for the specimens after immersion in water are to be not less than 90% of the values obtained from the unconditioned specimens.

(b) Compressive tests

The values of the modulus of elasticity E_c

and the ultimate compressive strength R_{mc} are to be determined by means of the relevant stresses-strains diagram.

The mean value is then determined as stated in (a), and is to be not less than that supplied by the manufacturer and, in any case, not less than the value obtained from the formulas in Table A4.2 or A4.3 as applicable.

(c) Flexural tests

The values of the modulus of elasticity E_{fi} and the ultimate flexural strength R_{mfi} of each of the ten specimens are to be determined by means of the relevant stresses/strains diagram.

The mean values of E_f and R_{mf} obtained as stated in (a) are to be not less than the values supplied by the manufacturer and, in any case, not less than the value obtained from the formulas in Table A4.2 or A4.3 as applicable.

(d) Interlaminar shear tests

The interlaminar shear strength obtained by determining the mean of the results of the individual specimens as stated in (a) is to be not less than the value recommended by the manufacturer and, in any case, not less than the value in Table A4.2 or A4.3 as applicable.

Table A4.2

Mechanical Properties	N/mm ²
E = tensile module of elasticity (0° or 90° direction)	75000 G_C - 6730
R_m = ultimate tensile strength (0° or 90° direction)	740 G_C - 65
R_{mc} = ultimate compressive strength (0° or 90° direction)	460 G_C - 40
R_{mf} = ultimate flexural strength	$R_{mf} = \frac{2,5 R_m}{\left(1 + \frac{R_m}{R_{mc}}\right)}$
R_{mtc} = ultimate interlaminar shear strength	35 Mpa

Appendix 4 - Carbon graphite fibres

Table A4.3

Mechanical Properties	Parallel to the fibres	Perpendicular to the fibres
E = tensile module of elasticity	151500 G _C - 15750	8025 G _C ² - 3150 G _C + 3300
R _m = ultimate tensile strength	1500 G _C - 150	38 G _C ² - 15 G _C + 15
R _{mc} = ultimate compressive strength	820 G _C - 82	1126 G _C ² - 45 G _C + 45
R _{mf} = ultimate flexural strength	$\frac{2,5R_m}{\left(1 + \frac{R_m}{R_{mc}}\right)}$	$\frac{2,5R_m}{\left(1 + \frac{R_m}{R_{mc}}\right)}$
R _{m_{ti}} = ultimate interlaminar shear strength	230 G _C ² - 180 G _C + 60	230 G _C ² - 180 G _C + 60

A4.7 RE-TESTS

Where the mean result is less than the value supplied by the manufacturer or, in general, where the value obtained from one of the specimens is less than the value given in Table A2.2 in Appendix 2, the test results are considered unsatisfactory.

In such case further specimens are to be selected, equal in number to the original and from the same panel, and re-tested.

Where the value found in this second group of specimens is less than that in Table A2.2 in Appendix 2, the final outcome is to be considered unsatisfactory and a new panel is to be fabricated.

The values obtained from these tests are to be added to those obtained previously in order to determine the arithmetic mean as stated in A4.6 (a) and such mean is to be not less than the values recommended by the manufacturer or those given in Table A2.2 in Appendix 2.

A4.8 TESTS FOR RENEWAL OF TYPE-APPROVAL

Where the fabrication process and materials used are unchanged with respect to the previous type-approval, renewal will be issued subject to the satisfactory outcome of a workshop survey and the repetition of the tests provided for in A4.5.2 (a) and (c).

Appendix 5 - Core materials for sandwich laminates

A5.1 GENERAL

The Rules contained in this Appendix apply to the type-approval of products for sandwich laminates.

The products considered are constituted by:

- balsa wood
- rigid expanded foam plastics.

Type-approval of other products will be considered in each case by ^{Tasneef} which will stipulate the procedures and tests for such products also on the basis of equivalence criterion.

"Rigid expanded form plastics" are intended to mean Expanded Polyurethanes (PUR) and Polyvinylchloride (PVC).

The foam is to be of the closed cell type and compatible with the proposed resin system (e.g. polyester, epoxide, etc.).

Foams are to be of uniform cell structure and maintain a satisfactory level of resistance to temperature up to 60°C, and to have a low water absorption.

They are to be resistant to environmental agents (water, oil fuels, lube oils) and information is to be provided on the dimensional stability of the foam by measurement of the shrinkage.

A5.2 CHARACTERISTICS AND REQUIREMENTS

Rigid expanded foam plastics are deemed suitable for use as sandwich laminates provided that:

- they are closed-cell;
- they are impervious to environmental agents (water, oil fuels, lube oils), both in the condition of supply and after ageing;
- they have low water absorption;
- they maintain a satisfactory level of resistance to temperature up to 60°C;
- they are compatible with laminating resins and gel coats.

Balsa wood is deemed suitable for use as sandwich laminates provided that:

- it is chemically treated against attacks from moulds and insects;
- it is oven dried immediately after being cut;
- it is sterilized and homogenized;
- it has an average humidity of 12%;
- where manufactured in formable sheets of small blocks, it has the open weave backing material and adhesive compatible with the laminating resins.

In addition to that required in item 3 of the general section of these Rules, the following further information is to be submitted to ^{Tasneef}

- trade name;
- type of material;
- description (block, scrim mounted, etc.);
- thickness;
- block/sheet dimensions;
- surface treatment.

Manufacturers are required to provide a full application procedure for use of the product.

mechanical properties as a function of the density:

- (a) ultimate tensile strength and modulus of elasticity;
- (b) ultimate compressive strength and modulus of elasticity;
- (c) ultimate shear strength and modulus of elasticity (not required in case of rigid expanded foam);

- for balsa wood manufactured in formable sheets of small blocks:

- (a) type of backing material;
- (b) type of adhesive.

A5.3 SAMPLING AND NUMBER OF SPECIMENS

The specimens are to be selected from panels taken from the production.

Where type-approval is requested for different densities, the specimens are to be selected from panels having the minimum and maximum densities among those submitted.

Where the range of densities is very wide, generally greater than four, specimens are also to be prepared from a panel with an intermediate density.

The number and dimensions of specimens to be selected from each panel chosen are as follows:

- 15 specimens of dimensions 300 x 100 x 10 mm for the tests of resistance to environmental agents and temperature, taken from a panel from which the surface film has been removed;
- 6 specimens of dimensions equal to those above for the tensile tests;
- 3 specimens of dimensions equal to those above for density
- 3 x 6 specimens for the tensile, compressive and shear tests. The dimensions of such specimens are those stipulated by the relevant standard requirements adopted for the tests.

In addition, 3 sandwich panels are to be prepared for the two (minimum and maximum) densities and, where applicable, for the mean density using glass (mat and woven roving) reinforcements deemed suitable by ^{Tasneef} for surface laminates.

Appendix 5 - Core materials for sandwich laminates

Each skin is to be identical and have a thickness between 3 and 4 mm and in general not greater than 21 per cent of the nominal core thickness. For hand laid constructions, each skin is to have a glass content between 0,45 and 0,50.

The method of construction of the sandwich laminate is to reflect the core material manufacturer's instructions for use, i.e. application of bonding paste, surface preparation or any other recommended system.

Where vacuum bagging techniques or equivalent systems are used these will be subject to special consideration.

The post curing conditions for samples of thermosetting resins are to be as indicated by the manufacturer and identical with those used for the finished product. The post curing conditions are to be those in which the resin is intended to be used. Where curing of the product is intended to take place at room temperature, the sample is to be

kept to cure at room temperature (>18 °C) for 24 hours followed by a post-cure at 40°C for 16 hours.

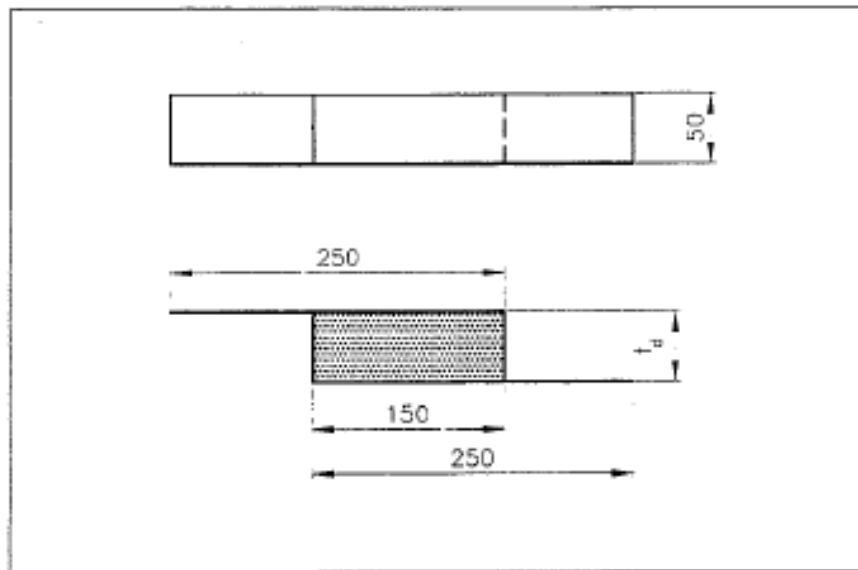
The thickness "t_d" of the core of every panel is to be equal to the minimum, average and maximum thickness values of the thickness range for which type-approval is requested by the manufacturer.

The following are to be taken from each of the above panels:

- 10 specimens, 5 L and 5 T, with the dimensions shown in Figure A5.1.

As an alternative the dimensions of the test samples are to be according to be based on the requirements of ASTM C393 Paragraph 5.1, and the ratio parameters as indicated in ASTM C393 Paragraph 5.2, using a proportional limit stress (F) for the woven roving skins of 130 N/mm² and a span (a²) of not less than 400 mm.

FIGURE A5.1



A5.4 TESTS

The specimens as required in A5.3 are to be subjected to the following tests:

- (a) resistance to environmental agents
 - 3 specimens immersed in sea water at ambient temperature for 24 hours;
 - 3 specimens immersed in gasoline at ambient temperature for 24 hours;
 - 3 specimens immersed in gas oil for motor vehicles at ambient temperature for 24 hours.
- (b) resistance to temperature

- 3 specimens heated in a stove for 30 minutes to 45°C;
 - 3 specimens heated in a stove for 30 minutes to 60°C;
- to be subjected to the tensile test immediately after removal from the stove.
- (c) density (ISO 845)
The value of the density to be not less than what declared by the Manufacturer.
 - (d) mechanical properties
 - tensile strength test (not required for rigid expanded foam plastics) and modulus of elasticity (ASTM D 1623 or

Appendix 5 - Core materials for sandwich laminates

ASTM C 297-61 speed = t/10mm/1'); the tensile test is also to be performed on specimens after immersion (see (a) above);

- compressive strength test and modulus of elasticity (ASTM D 1621 or ISO 844 speed t/10mm/1');
- shear strength test and modulus of elasticity (ASTM C 273 or ISO 1922 speed = 1mm/1').

The standards given above are intended for expanded foam plastics; for balsa wood the test reported in Table A5.1 (standard requirements recognized by ^{Tasneef} and proposed by the manufacturer may be adopted for balsa wood).

Table A5.1

Test	Standard
Density	ISO 845-1977
Tensile strength	ASTM C297- 61 (speed = t/10 mm/1')
Compressive strength	ISO 844 (speed = t/10 mm/1')
Shear strength	ISO 1922 (speed = 1 mm/1')

- (e) compatibility with laminating resins and gel coats

The specimens taken from the 3 sandwich panels are to be subjected to an interlaminar shear test by inserting the edges in the grips for the tensile test and providing a device against lateral deflections.

After determining the load **P**, in N, at which the rupture begins, the corresponding stress τ , in N/mm², is to be derived from the formula:

$$\tau = \frac{P}{150 \times 50}$$

As alternative the samples are to be subjected to four-point flexural tests to determine the apparent shear properties according to ASTM C393 (short beam) at two representative thicknesses. Testing is to be carried out at ambient temperature and after 30 minutes to 60°C.

A5.5 EVALUATION OF TEST RESULTS

- (a) Resistance to environmental agents

After immersion the specimens are to be kept hanging in air for 24 hours to allow dripping, then measured and weighed to

check the variation in volume ΔV and weight ΔG with respect to dry volume and weight prior to immersion.

Each specimen is to produce the following result:

$$\Delta V \leq 1\%;$$

$$\Delta G \leq 6\%;$$

The ultimate tensile strength of the above specimens is to be $\geq 0,90 R_m$, R_m being the ultimate tensile strength of the material as supplied.

- (b) Resistance to temperature
The ultimate tensile strength is to be:

$\geq 0,9 R_m$ for specimens heated to 45°C;

$\geq 0,8 R_m$ for specimens heated to 60°C;

R_m being the ultimate tensile strength of the material as supplied.

- (c) Mechanical properties

The mechanical properties (tensile (not required for rigid expanded foam plastics), compressive and shear strength and corresponding moduli of elasticity) are, in general to be not less than the values given in Figures A5.2 ÷ A5.5 for expanded foam plastics and in Table A5. 5 for balsa wood.

In any case the values of the mechanical properties are to be not less than those supplied by the manufacturer

- (d) Compatibility with laminating resins and gel coats

The stress τ , in N/mm², for each specimen is to be $\geq R_{mt}$, R_{mt} being the ultimate longitudinal shear strength of the core material.

The position where the rupture starts is to be indicated in the test documentation

The minimum mechanical properties are those reported in Table A5.2 for laminate with glass or aramid fiber and in Tables A5.3 and A5.4 for carbon fiber.

Appendix 5 - Core materials for sandwich laminates

Table A5.2 minimum mechanical properties for laminate with glass or aramid fiber

R_m = ultimate tensile strength	$= 1278 G_c^2 - 510 G_c + 123$	85
E = tensile modulus of elasticity	$= (37 G_c - 4,75) \cdot 10^3$	6350
R_{mc} = ultimate compressive strength	$= 150 G_c + 72$	117
E_c = compressive modulus of elasticity	$= (40 G_c - 6) \cdot 10^3$	6000
R_{mf} = ultimate flexural strength	$= (502 G_c^2 + 107)$	152
E_f = flexural modulus of elasticity	$= (33,4 G_c^2 + 2,2) \cdot 10^3$	5200
R_{mi} = ultimate shear strength	$= 80 G_c + 38$	62
G = shear modulus of elasticity	$= (1,7 G_c + 2,24) \cdot 10^3$	2750
R_{mi} = ultimate interlaminar shear strength	$= 22,5 - 17,5 G_c$	17

Table A5.3 minimum mechanical properties for carbon fiber

Mechanical Properties	N/mm ²
E = tensile module of elasticity (0° or 90° direction)	$75000 G_c - 6730$
R_m = ultimate tensile strength (0° or 90° direction)	$740 G_c - 65$
R_{mc} = ultimate compressive strength (0° or 90° direction)	$460 G_c - 40$
R_{mf} = ultimate flexural strength	$R_{mf} = \frac{2,5 R_m}{\left(1 + \frac{R_m}{R_{mc}}\right)}$
R_{mtc} = ultimate interlaminar shear strength	35 Mpa

Table A5.4 minimum mechanical properties for carbon fiber

Mechanical Properties	Parallel to the fibres	Perpendicular to the fibres
E = tensile module of elasticity	$151500 G_c - 15750$	$8025 G_c^2 - 3150 G_c + 3300$
R_m = ultimate tensile strength	$1500 G_c - 150$	$38 G_c^2 - 15 G_c + 15$
R_{mc} = ultimate compressive strength	$820 G_c - 82$	$1126 G_c^2 - 45 G_c + 45$
R_{mf} = ultimate flexural strength	$\frac{2,5 R_m}{\left(1 + \frac{R_m}{R_{mc}}\right)}$	$\frac{2,5 R_m}{\left(1 + \frac{R_m}{R_{mc}}\right)}$
R_{mti} = ultimate interlaminar shear strength	$230 G_c^2 - 180 G_c + 60$	$230 G_c^2 - 180 G_c + 60$

Table A5.5 minimum mechanical properties for balsa wood

Density (kg/m ³)	Ultimate strength (N/mm ²)				Shear	Compressive modulus		Shear modulus of elasticity (N/mm ²)
	Compressive		Tensile			Stress direction		
	Stress direction							
	Parallel to fibres	Perpendicular to fibres	Parallel to fibres	Perpendicular to fibres		Parallel to fibres	Perpendicular to fibres	
96	5,00	0,35	9,00	0,44	1,10	22,75	35,20	105
144	10,6	0,57	14,6	0,70	1,64	39,00	67,8	129
175	12,80	0,65	20,60	0,80	2,10	52,90	98,60	145

Appendix 5 - Core materials for sandwich laminates

A5.6 RE-TESTS

The test results are considered satisfactory if the arithmetic mean of the values obtained from the specimens is not less than the values required in the individual tests.

Failing this, the test results are considered unsatisfactory; in such case, at the request of the Interested Party, a second round of tests may be performed on a second series of specimens.

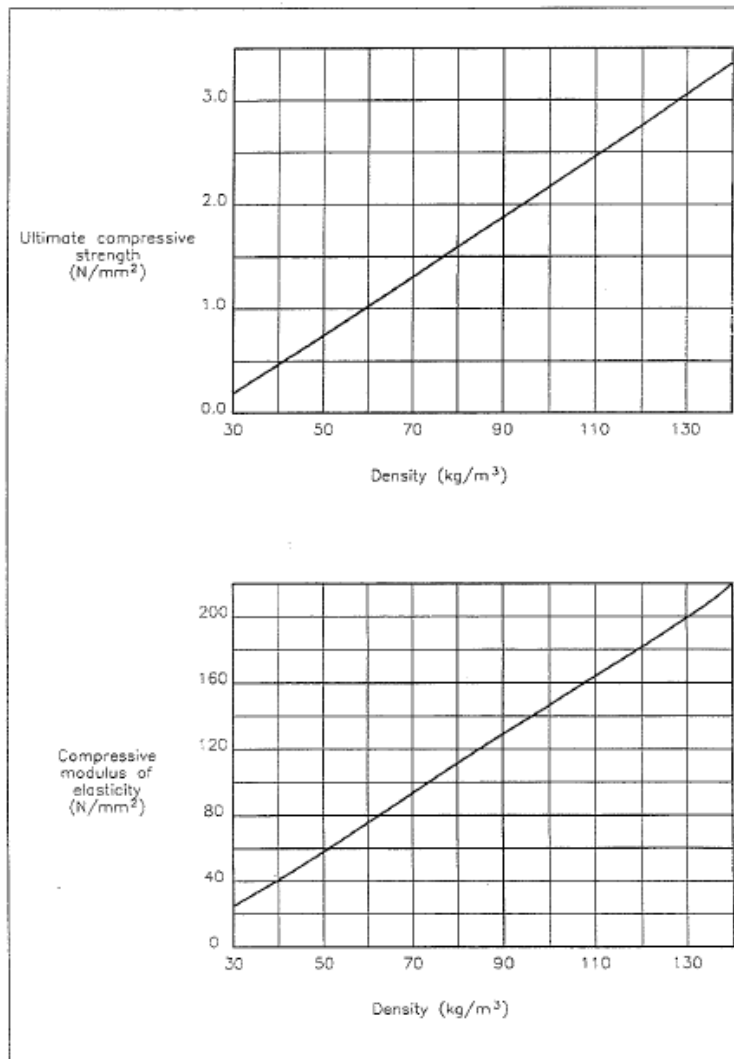
It is acceptable for one of the specimens to give results less than the reference values but in any case not less than 85% of the reference value.

A5.7 TESTS FOR RENEWAL OF TYPE-APPROVAL

Where the fabrication process and materials used are unchanged with respect to the previous type-approval, renewal will be issued subject to the satisfactory outcome of a workshop survey and the repetition of the tests provided for in A.5.4 (d).

FIGURE A5.2

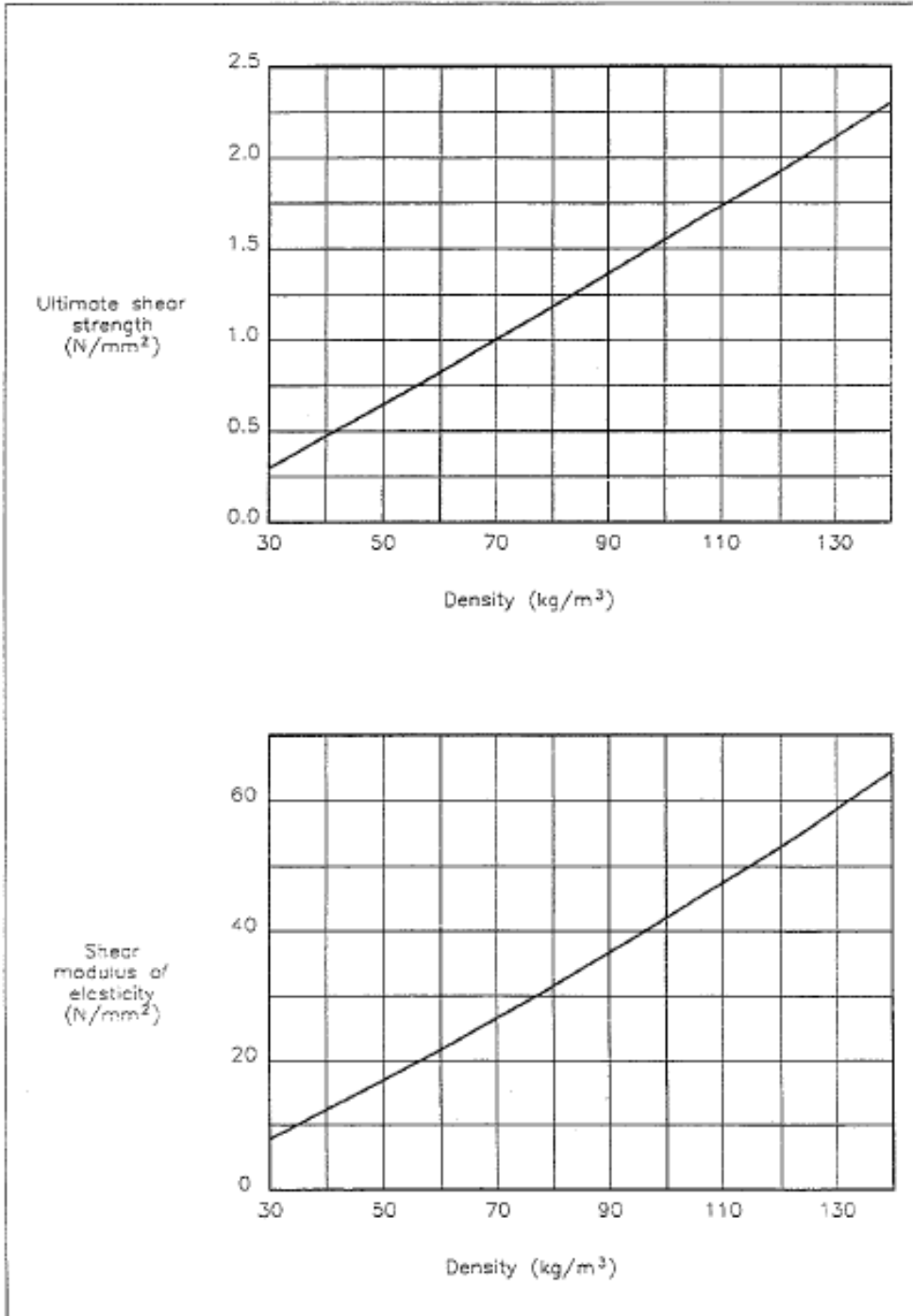
PROPERTIES OF PVC TYPE EXPANDED FOAM PLASTICS



Appendix 5 - Core materials for sandwich laminates

FIGURE A5.3

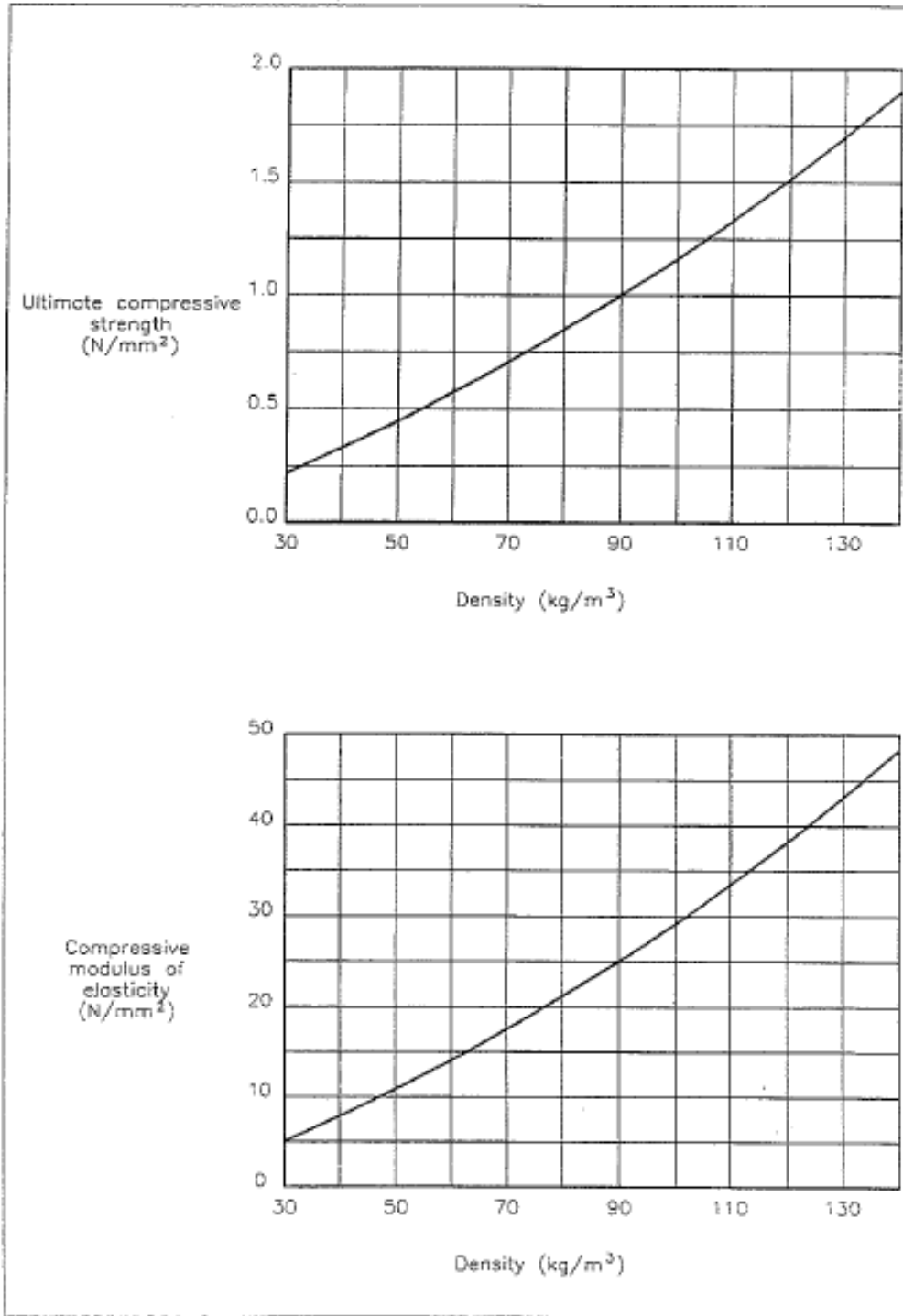
PROPERTIES OF PVC TYPE EXPANDED FOAM PLASTICS



Appendix 5 - Core materials for sandwich laminates

FIGURE A5.4

PROPERTIES OF PUR TYPE EXPANDED FOAM PLASTICS



Appendix 5 - Core materials for sandwich laminates

FIGURE A5.5

PROPERTIES OF PUR TYPE EXPANDED FOAM PLASTICS

