SAE Aerospace
An SAE International Group

AEROSPACE MATERIAL SPECIFICATION

SAE AMS 2980/1A

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Superseding AMS 2980/1

Carbon Fiber Fabric and Epoxy Resin Wet Lay-Up Repair Material Part 1 - General Requirements

RATIONALE

AMS 2980/1 is revised to include the relevant PRI documentation references and the PRI rules to manage the qualification material process through the Qualified Product Group (QPG). Test method lists in Paragraph 2 have been updated.

FOREWORD

AMS 2980/1 belongs to the Technical Specification system explained in AMS 2980.

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1. SCOPE:

AMS 2980/1 gives information about the technical requirements and qualification procedure for carbon fiber fabric and epoxy resin systems used for wet lay-up repair of carbon fiber reinforced epoxy structures.

2. APPLICABLE DOCUMENTS:

The issue of the following documents in effect on the date of the purchase order forms a part of this specification to the extent specified herein. The supplier may work to a subsequent revision of a document unless a specific document issue is specified. When the referenced document has been cancelled and no superseding document has been specified, the last published issue of that document shall apply

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001 or www.sae.org.

AMS 2980	Technical Specification: Carbon Fiber Fabric and Epoxy Resin Wet Lay-Up Repair Material - Part 0 - Introduction
AMS 2980/2	Technical Specification: Carbon Fiber Fabric and Epoxy Resin Wet Lay-Up Repair Material - Qualification Program
AIR4844	Composites and Metal Bonding Glossary
ARP4916	Masking and Cleaning of Epoxy and Polyester Matrix Thermosetting Composite Materials

2.2 ASTM Publications:

Available from ASTM, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959 or www.astm.org.

ASTM C 297	Flatwise Tensile Strength of Sandwich Constructions
ASTM C 393	Flexural Properties of Sandwich Constructions
ASTM D 1652	Epoxy Content of Epoxy Resins
ASTM D 1875	Density of Adhesives in Fluid Form
ASTM D 2471	Gel Time and Peak Exothermic Temperature of Reacting Thermosetting Resins
ASTM D 2896	Total Base Number of Petroleum Products by Potentiometric Perchloric Acid Titration
ASTM D 3039/3039M	Tensile Properties of Polymer Matrix Composite Materials
ASTM D 3518/3518M	In Plane Shear Response of Polymer Matrix Composite Materials by Tensile Test of a ±45° Laminate
ASTM D 3990	Terminology Relating to Fabric Defects
ASTM D 5766/5766M	Open Hole Tensile Strength of Polymer Matrix Composite Laminates
ASTM E 1252	General Techniques for Obtaining Infrared Spectra for Qualitative Analysis

2.2 (Continued):

ASTM E 1640	Assignment of the Glass Transition Temperature by Dynamic Mechanical Analysis
ASTM E 4	Force Verification of Testing Machines
ASTM E 203	Water Using Karl Fischer Reagent

2.3 EN Publications:

Available from CEN-comité, Europeén de Normalisation, Secrétariat Central, Rue de Stassart 36, B-1050 Bruxelles, Belgium or www.cenorm.be.

EN 542	Adhesives. Determination of density
EN 2379	Test Fluids for Nonmetallic Materials
EN 2489	Fiber Reinforced Plastics - Action of Liquid Chemicals
EN 2561	Carbon Thermosetting Resin Unidirectional Laminates - Tensile Test Parallel to the Fiber Direction
EN 2564	Aerospace series. Carbon fibre laminates. Determination of the fibre, resin and voids contents
EN 2743	Aerospace series. Standard procedure for conditioning prior to testing
EN 2823	Fiber Reinforced Plastic - Effect of Exposure to Humid Atmosphere on Physical Characteristics
EN 2850	Fiber Reinforced Plastic - Unidirectional Laminates and Woven Fabric Laminates-Compression Test
EN 6031	Fiber Reinforced Plastic - In-plane Shear Properties (45° Tensile Test)
EN 6032	Glass Transition Temperature (DMA)
EN 6035	Fiber Reinforced Plastic - Notched and Unnotched Tensile Test
EN 6037	Fiber Reinforced Plastic - Bearing Strength
EN 6038	Fiber Reinforced Plastic - Compression Strength after Impact
EN 6042	Organic Compounds by Infrared Spectroscopy
EN 6043	Gel Time and Viscosity of Matrix Resins
EN 6061	Sandwich Flexural Test - 4 Point Bending
EN 6062	Fiber Reinforced Plastics - Flatwise Tensile Test of Composite Sandwich Panel
EN 6064	Aerospace series. Fibre reinforced plastics. Test method. Determination of the extent of cure by differential scanning calorimetry
EN 6066	Fiber Reinforced Plastics - Tensile Strength of Tapered and Stepped Joints

2.4 ISO Publications:

Available from ISO, Central Secretariat, 1 Rue de Varembé, Case postale 56, CH-1211 Geneve 20, Switzerland or www.iso.org.

ISO 472	Plastics – Vocabulaire
ISO 760	Determination of water. Karl Fischer method (general method)
ISO 868	Hardness Shore D
ISO 1183	Density and Relative Density of Non-Cellular Plastics
ISO 1890	Carbon Fiber - Twist

2.4 (Continued):

ISO 2555	Brookfields RV Viscosity
ISO 3001	Epoxide Equivalent
ISO 9001	Quality Control by Supplier
ISO 11357-5	Plastics. Differential scanning calorimetry (DSC). Curve temperatures and times, enthalpy of reaction and degree of conversion
ISO 1890	Carbon fibre. Determination of twist
ISO 10119	Carbon Fiber - Density
ISO 10120	Carbon Fiber - Linear Density
ISO 10548	Carbon Fiber - Size Content
ISO 10618	Carbon Fiber - Tensile Properties by Resin Impregnated Yarn Specimens

2.5 PRI Publications:

Available from Performance Review Institute, 161 Thornhill Road, Warrendale PA 15086-7527 or www.pri-network.org.

PD 2000	Governance and Administration of an Industry Managed Product Qualification Program
PD 2001	Manufacturer Request for Product Approval and Qualification Process
PRI QPL AMS 2980	Qualified Product List of AMS 2980.

2.6 SACMA Publications:

Available from Suppliers of Advanced Composite Materials Association, 1600 Wilson Boulevard, Suite 1008, Arlington, VA 22209.

SACMA 3	Open-Hole Compression Properties of Oriented Fiber-Resin Composites, Issue 1994

3. DEFINITIONS:

3.1 General:

For the purpose of this standard the definitions in ISO 472 apply with the following additions or modifications. For further definitions or explanation of terms, refer to AIR4844.

3.2 Specific for Carbon Fiber/Fabric and Resin Materials:

BOBBIN: All yarn contained on one spool.

CARBON FIBER BATCH: Bobbins produced in one continuous manufacturing operation that conforms to a fixed manufacturing process in accordance with the Process Control Document (PCD) and is made of one creel set of precursor. A continuous manufacturing operation is defined as one in which the process is not interrupted for more than 24 hours or by a different production run.

FABRIC ROLL: Woven fabric contained on one support tube. The fabric on the roll shall originate from one single master roll of woven fabric.

MASTER ROLL OF WOVEN FABRIC: Woven fabric material that is manufactured in one continuous operation from which several smaller fabric rolls are taken.

PROCESS CONTROL DOCUMENT (PCD): Document defining the material and its manufacturing process. The PCD shall include description of raw materials, equipment, procedures, processes and manufacturing standards.

RESIN BATCH: A quantity of homogeneous resin (base resin and curing agent) prepared in one operation with traceability to individual component batches as defined in the PCD of the resin system manufacturer.

REPLICA: Production of a defined material of an original source on another production line and/or a different site using the same raw materials and processes as the original source.

SIZING: An organic coating. It is applied during fiber manufacture to improve handling properties during weaving.

WOVEN FABRIC: Fiber yarns woven into a fabric of any two-dimensional weave pattern. Warp and weft tracer fibers of another material may be incorporated into the fabric.

WOVEN FABRIC BATCH: A quantity of fabric of a certain weaving style produced on a certain loom in accordance with the PCD. The production run of the batch shall be a continuous operation and shall not be interrupted by a run of a different material.

YARN: A bundle of fibers usually twisted and suitable for making fabric.

4. REQUIREMENTS:

4.1 General Requirements:

4.1.1 Qualification: All products sold to this specification shall be listed, or approved for listing, on the qualified products list PRI QPL AMS 2980. The qualified products list shall be in accordance with PD 2000.

4.1.2 Process Control Document: Prior to manufacturing the first qualification fiber, fabric or resin batch, the manufacturer shall have established the PCD. The PCD shall be presented to the CACRC-QPG upon request. CACRC-QPG shall treat any information contained in the PCD as confidential.

Changes to the PCD of a qualified material are subject to the written approval of the CACRC-QPG in accordance with PD 2000. Such changes may require side qualification. The batch release test report for the first delivery made after any change to the PCD shall contain a reference to the change.

4.1.3 Traceability: Each individual material shall be identifiable at all stages of manufacture and delivery. The material manufacturer shall present evidence of the material traceability upon request.

4.1.4 Health and Safety Requirements: The delivered fiber, fabric and resin system shall fulfill the local requirements of the health and safety laws of the country of the purchaser.

In processing the materials in the composite shop, the fabric/resin combination shall not cause any health problems or cause an emission which requires special measures to be taken to protect the environment.

The manufacturer shall inform the purchaser regarding safe handling procedures of the material. The resin system formulation given to the CACRC-QPG during qualification shall also be inspected for health and safety requirements.

4.1.5 Manufacturer's Responsibility: The manufacturer is responsible for the development and manufacture of any material submitted in accordance with this TS. Quality control by the manufacturer shall be in accordance with this TS. The material manufacturer commits itself to supply a qualified material for a minimum of ten years.

Adjustment of manufacturing techniques and /or procedures to the state of the art technology is the manufacturer's responsibility and may require requalification to this specification.

4.1.6 Quality Assurance: The manufacturer's quality system shall be approved as defined in ISO 9000 or equivalent.

4.2 Technical Requirements:

4.2.1 Technical Requirements for Carbon Fibers:

4.2.1.1 Fiber: The carbon fiber used to weave the fabric according to this TS shall be a material qualified in prepreg form for one of the epoxy prepreg specifications used to manufacture assemblies for a commercial aircraft by an OEM. For this qualification program re-qualification of the fiber is not required provided that the specified tests have been performed in the original qualification program. The original qualification test data shall be used for evaluation of the properties. The carbon fiber yarn shall meet the requirements of the MS.

4.2.1.2 Pretreatment and Sizing: The PCD shall specify appropriate control of fiber pretreatment and sizing chemistry. The sizing when applied shall meet the requirements of the MS. After qualification the size type and content shall be defined in the IPS.

4.2.1.3 Fiber Splices: The fiber yarn on each bobbin shall contain no more than seven splices per kilogram of yarn.

4.2.2 Technical Requirements for Fabric:

4.2.2.1 Woven Fabric: The fabric shall be woven from fiber qualified in accordance with paragraph 4.2.1. Looms used to weave fabrics for wet lay-up repair shall also be in use for weaving fabrics that are qualified in a prepreg form used to manufacture assemblies for a commercial aircraft by an OEM. No more than three fiber batches shall be used in the warp direction and one fiber batch in the weft direction for any single fabric batch. Alternatively, if one batch is used in the warp direction, no more than three batches shall be used in the weft direction. The fiber orientation for the warp and the weft shall be 0° and 90°, respectively. The material, tooling and methods used for weaving and handling shall not affect the carbon fiber or cause contamination of the fabric. Each roll in a fabric batch shall meet the length requirements of the PS for carbon fabric. The fabric manufacturer shall assign consecutive fabric roll numbers. Roll number assignment may be done:

1. at the time of weaving or
2. at the time these rolls are wound from master rolls.

The woven fabric shall meet the requirements of the MS.

4.2.2.2 Fabric Requirements: The incorporation of glass tracer yarns may be agreed upon between the purchaser and the fabric manufacturer. The tracers shall be woven approximately every 50 mm in the warp direction and every 150 mm in the weft direction. Aramid fiber tracers shall not be used.

The selvage shall be of such width (38 mm maximum) as to cause no distortion of the fabric when the material is unrolled.

The fabric width, which excludes selvage, shall be specified in the IPS. The width tolerance shall be ±12.5 mm for each meter of fabric width.

The material shall be wound on the support tube, in a way that when unrolled on a flat surface, it will retain edges that are straight within ±25 mm in a 15 m length.

Carbon fabric may be spliced to meet material roll length requirements. Splices shall be overlapped a maximum of 300 mm with a maximum of one splice per roll. Material splices shall not be within 10 m of the end of the roll. Material splicing deviations shall be allowed when agreed upon between purchaser and the fabric manufacturer.

Each defect shall be identified and flagged with a colored mark positioned on the fabric. A continuous defect shall be identified with a colored mark at the start and with a different colored mark at the end of the defect.

Each roll shall have a defect record attached, recording the location and length of each defect (if any) in that roll.

4.2.2.3 Woven Fabric Defects: Definition of defect description terms are in accordance with ASTM D 3990.

A defect area is the length of the defect, if that defect exceeds specified limits, multiplied by the roll width. The cumulative defective area of a roll shall not exceed 10% of the roll area.

Single yarn defects, such as broken fibers, distortions and wrinkles, shall not be more than three over 2.0 m of fabric. Each defect shall be spaced apart 150 mm minimum. If two single yarn defects are closer than 150 mm, they shall be considered as a continuous defect.

Continuous weaving defects, such as wrinkles, cut fibers, and crushed distorted yarns, shall be considered a continuous defect if they involve more than one yarn. Multiple defects such as missed pick, missing end, whipped in weft, loose pick, slab, kink, and fuzz ball shall be considered a continuous defect if they involve more than one yarn.

A continuous single yarn or weaving defect shall not exceed 170 mm in any linear meter where no defect is closer than 150 mm to another.

Splices of adjacent yarns shall be spaced apart 12.5 mm minimum. A fabric roll shall contain not more than one splice across the fabric width, see paragraph 4.2.2.2.

Warp yarn deviation from a straight line shall be 5 mm maximum over 1.0 m of fabric length. Weft yarn deviation from a straight line shall be 50 mm maximum over 1.0 m of fabric width.

4.2.2.4 Storage Conditions for Carbon Fabrics: The fabric shall be stored wrapped in plastic in a clean and dry area. The fabric roll shall not be allowed to lay on a surface, stand on its end, and/or have any other rolls or objects placed on top of it.

4.2.2.5 Storage Life of Carbon Fabrics: When stored in accordance with paragraph 4.2.2.4 the fabrics shall have a minimum storage life of two years from the date of receipt. The maximum storage time shall be specified by the fiber manufacturer and shall be stated in the IPS. The storage life shall be guaranteed by the weaver and the fiber manufacturer. At the end of the storage life, the fiber, fabric and composite shall meet the requirements of this TS and the MS. Storage life extension procedures may be described in the IPS.

4.2.3 Technical Requirements for Resin System:

4.2.3.1 Nominal Process Parameters for Qualification: Prior to qualification the manufacturer and CACRC-QPG shall agree upon the nominal blending proportions of the base resin and the curing agent, the blending instructions and the nominal cure cycle; see paragraphs 4.2.3.3 and 4.2.3.8. These nominal process parameters shall be specified in the IPS. The nominal cure cycle may contain a dwell to comply with viscosity requirements. AMS 2980/2 specifies process parameters based on the nominal parameters. Cure cycles and blending ratios not tested in accordance with this TS are non-qualified process parameters and shall not be included in the IPS.

4.2.3.2 Appearance: Each component of the resin system shall be a homogeneous material and shall meet the requirements of this TS and the MS.

4.2.3.3 Blending: The blending ratio shall be the amount of the curing agent expressed in terms of parts by mass of curing agent for 100 parts by mass of base resin. Base resin and curing agent shall blend readily to produce a uniform material when mixed by hand for a minimum of 3 minutes in a suitable container.

4.2.3.4 Water Content: The resin manufacturer shall recommend a maximum water content for both base resin and curing agent based on the material manufacturer and repair shop conditions. This maximum value shall be demonstrated acceptable at time of qualification in accordance with TS and shall be specified in the IPS. All base resin and curing agent delivered in accordance with this specification shall have a water content less than this amount.

4.2.3.5 Color: Color shall be used for visual identification of the materials. The color of the resin shall be different from the color of the curing agent to avoid exchange by mistake. There are no special requirements for the color of the resin system unless otherwise specified in the MS. The color of the base resin and the curing agent shall be uniform.

4.2.3.6 Storage Life of the Resin System: At the end of the defined storage life the base resin and curing agent shall meet all requirements of this TS and the MS. Storage life extension procedures may be described in the IPS. The storage life of base resin and curing agent shall meet the following requirements:

a. The storage life of unopened containers from the date of receipt at any purchaser worldwide: 12 months minimum at storage conditions to be defined by the manufacturer and specified in the IPS
b. Storage life of kitted and unopened containers at room temperature shall be six months minimum and shall be specified in the IPS.

4.2.3.7 Properties of the Base Resin and Curing Agent: The base resin and curing agent shall meet the requirements of the MS when tested in accordance with AMS 2980/2.

4.2.3.8 Properties of the Uncured and Cured Neat Resin: The uncured resin system shall meet the requirements of the MS when blended and tested in accordance with AMS 2980/2. The cured neat resin shall meet the requirements of the MS when blended, cured and tested in accordance with AMS 2980/2.

4.3 Requirements for Composite Materials:

The performance level of the composite material, achieved in the qualification testing as specified in AMS 2980/2, shall meet the values specified in the MS when subjected to the statistical method of paragraph 5.6.

4.4 Test Methods:

Test methods shall be in accordance with the standard test procedures given in this TS. This section describes modifications or additions to the standard test methods. If there is no standard test method available, this section specifies the test method to be used.

4.4.1 Required Number of Specimens: The required numbers of test specimens are listed in AMS 2980/2.

4.4.2 Test Methods for Fiber: Test methods for the fiber properties are listed in AMS 2980/2. These test methods shall be used unless written approval is given by the CACRC-QPG for using alternative test procedures. It is the responsibility of the fiber manufacturer to demonstrate the correlation of his proposed test method with the methods specified.

4.4.3 Test Methods for Fabric: The fabric test methods are defined in AMS 2980/2.

4.4.3.1 Fiber Areal Mass: The fiber areal mass shall be determined by weighing a 100 mm by 100 mm sample and dividing the mass in grams by the measured sample area in square meters. The fiber areal mass to be reported is the average of three samples taken across the width of the roll.

4.4.3.2 Yarn Count: Yarn count shall be determined by measuring the yarns in both the warp and weft directions on three separate sample areas of minimum 100 mm by 100 mm across the width of the roll. Calculate the yarn count by dividing the number of yarns counted by the actual dimension of the test sample perpendicular to the yarns counted in mm. The yarn count in each direction to be reported is the average of the counts on the three samples.

4.4.4 Test Methods for Resin System: Test methods accepted for characterisation of the resin system are defined in AMS 2980/2.

Since the chemical composition of the resin system under test is not fixed by this specification, in order to achieve optimum results these test methods generally require, before test, selection of the appropriate test equipment and establishment of suitable test parameters. Since these decisions may affect the outcome of the test, test reports shall include all information required to allow independent reproduction of the test results, even if not specifically required by the test method.

It shall be the responsibility of the qualifier to determine and agree on the detailed procedures and to present the test results accordingly.

Requirements fixed in the relevant Material Specification shall make reference to the test method applied. If other test methods are to be used, correlation tests shall be performed.

4.4.5 Test Methods for Composites: The specimen manufacturing and the test methods are described in Section 6.

5. QUALIFICATION:

5.1 Introduction:

Before approving a fiber fabric and resin system combination for repair it shall successfully complete three stages:

a. Screening according to the screening program specified in AMS 2980/2 to verify the suitability of the material combination for qualification.
b. Qualification of the material combination in accordance with AMS 2980/2.
c. Additionally, each OEM referencing the specification may require additional tests before this material combination is approved for repair purposes.

5.2 Material Qualification:

5.2.1 General: The qualification shall be carried out by the material manufacturers. A liaison between CACRC-QPG and manufacturers shall be undertaken to agree on work and any necessary coordination. If the manufacturer cannot perform the required tests, a material test laboratory acceptable to the CACRC-QPG shall be appointed. The screening and qualification program may be witnessed by CACRC-QPG and/or airworthiness authority representatives. The manufacturer shall keep on file and at the disposition of CACRC-QPG all records (test graphs, process parameters, etc.) corresponding to the qualification for at least five years.

5.2.2 Screening of a Material Combination: The screening test program may be a part of the qualification and should be done by the manufacturers. A sample of the same batch of the material used for screening by the manufacturer shall be sent to CACRC-QPG to perform either screening tests or reference tests on their own, and run production shop trials with the material.

The tests which shall be carried out are defined in AMS 2980/2. Material requirements are defined in the MS. The process parameters agreed between the resin manufacturer and CACRC-QPG shall be used; see paragraph 4.2.3.1.

The results of the screening tests shall be collected in a report. A successful screening test report, certified by the CACRC-QPG is prerequisite to start qualification.

5.2.3 Qualification of Material: The qualification is directed to the raw material sources, the equipment and the processes which have been identified in the PCD. The qualification is also directed to the material combination, i.e., the composite. The tests required are defined in AMS 2980/2. Material requirements are defined in the MS.

5.2.3.1 Cross-Check: If required by CACRC-QPG , a sample from one batch of the material shall be provided to CACRC-QPG to permit a cross-check to confirm that all qualification data supplied is comparable.

5.2.3.2 Additional Tests by OEM Outside of the Qualification Program: The OEM may require tests to demonstrate:

a. Compatibility of the resin system with other materials (e.g., adhesive films, core splice, potting compound, etc.)
b. The adhesion of the resin/composite to structure to be repaired.
c. Specific tests applicable to parts to be repaired.

5.2.4 Audit of a Manufacturer: The manufacturer shall agree to an audit of the product manufacturing operations, Quality Control System, raw material traceability, process records, test procedures, test results and quality control records. Qualification audits shall be conducted during the manufacture of qualification batches.

CACRC-QPG reserves the right to perform an on-site audit on the manufacturing of any batch of qualified material.

5.2.5 Establishment of an IPS: Upon successful qualification an IPS shall be established by CACRC-QPG and the qualified material combination shall be added to the PRI QPL AMS 2980. In addition to the performances the IPS shall provide the qualified repair process parameters (blending ratio, cure cycle), cross references to the relevant in-house specifications of the manufacturers (PCD, etc.) and other items and agreements describing the material and its controls. Requirements and performances shall be given in both SI and imperial units (imperial units in brackets). The IPS shall receive official acknowledgment from the material manufacturers as basis for future deliveries.

5.3 Material Qualification Program:

The manufacturer and CACRC-QPG shall agree on the procedure for the test program. The material tested in the qualification shall be manufactured on the same equipment and in accordance with the same specification and process procedures as the production material which will be delivered. The qualification tests for fiber, fabric, resin system and composite are specified in AMS 2980/2.

In the material qualification program the following are applicable:

The first qualification batch may be the same as the one which has been used for the screening tests, so that the results of the screening can be incorporated in the qualification results.

Three different manufacturing procedures are used to make the composite specimens:

a. The squeeze out procedure for making laminates; see paragraph 6.7.6.
b. The vertical bleeding procedure for making laminates; see paragraph 6.7.7.
c. The vertical bleeding procedure for making sandwich panels; see paragraph 6.7.8.

The process parameters agreed between the resin manufacturer and CACRC-QPG shall be used; see paragraph 4.2.3.1.

5.3.1 Qualification Retests: A retest may be required when one or more test results do not meet the requirements. A retest shall be performed on material from the same batch or batches agreed with CACRC-QPG. The quantity of test specimens shall be doubled. Material failing on retest shall be rejected and shall not be retested again without written approval by CACRC-QPG.

5.3.2 Qualification Test Report: The qualification test report shall contain at least the following information:

a. Complete identification of the material tested, including type, source, manufacturer's identification, batch numbers, certificates, etc., and shall reference the PCD.
b. All details regarding specimen preparation as described in Section 6 including processing and inspections.
c. Traceability of specimens to the original laminate and processing conditions; see paragraph 6.3.
d. Aging and/or conditioning data prior to the test in accordance with paragraph 6.2.
e. Date of test, facility, equipment and identification of individuals performing the tests.
f. All test and retest data including reference to test methods used.
g. Individual values, arithmetic mean and standard deviations per group of specimens.
h. The material properties shall be reported in both SI and imperial units.
i. Any incident which may have affected the results and any deviation from this specification.

5.4 Side Qualification and Requalification:

If any change occurs relevant to the IPS or the PCD, the CACRC-QPG reserves the right to require a side qualification by the manufacturer. The side qualification program depends on the nature of the change of the material or the material processing. Baseline side qualification programs are listed in Table 1.

TABLE 1 - Side Qualification Program

Fiber	Fabric	Resin	Side qualification program[1]
Replica of qualified source	Qualified	Qualified	Full qualification program except resin tests
New source	Qualified	Qualified	Full qualification program except resin tests
Qualified	New weaver	Qualified	Selected composite tests
Qualified	Qualified weaver; new loom	Qualified	Selected composite tests
Qualified	Other fabric style	Qualified	Full qualification program except resin tests
Qualified	Qualified	Replica of qualified source	All resin tests and selected composite tests
Qualified	Qualified	New source	Full qualification program

[1] The qualification program for fiber yarns, carbon fiber fabrics, resin and the material combination is defined in AMS 2980/2.

5.5 Material Safety Data Sheet:

The material manufacturer shall provide to the CACRC-QPG all the information about the material in accordance with health and safety requirements (See paragraph 4.1.3) prior to testing the materials for screening or qualification. The manufacturer shall make available a public Material Safety Data Sheet (MSDS) upon delivery which shall comply to the local laws of the OEM in CACRC-QPG and/or purchaser.

5.6 Evaluation of Test Data:

Material qualification test data shall be evaluated by CACRC-QPG:

a. To determine the material performance to be defined in the IPS.
b. To determine if a source meets the requirements of the MS.
c. To determine the batch release requirements.

6. COMPOSITE TEST METHODS AND SPECIMEN MANUFACTURING:

This section specifies the composite test methods, specimen manufacturing, fluid immersion and aging procedures by referring to existing standards and specifying additions and changes to them. These alterations override the requirements of the referenced standards.

6.1 Specimen Manufacturing and Storage:

6.1.1 Specimen Definition: The number of specimens per test condition and the specimen lay-up are specified in AMS 2980/2.

6.1.2 Panel Size: The panel size shall be such that:

a. All specimens for the same test method, regardless of the test condition, can be cut from the same panel.
b. Additional requirements for combining specimens in one panel may be specified in AMS 2980/2.

If this cannot be accomplished the report shall state which specimens were taken from which panel.

An edge cut all around shall be made with sufficient width to remove the area with fiber orientation distortion and deviating panel thickness. An edge cut of 20 mm may be sufficient. It is recommended that the panel's size is adequate to provide for:

a. Spare specimens; see paragraphs 6.1.8 and 6.5.1.3.
b. Traveller specimens; see paragraph 6.2.2.

6.1.3 Panel Manufacturing: Two repair processes are specified for making laminate panels (squeeze-out and vertical bleeding) and one procedure for making sandwich panels (vertical bleeding):

a. Process the panels in accordance with AMS 2980/2 and methods specified in paragraph 6.7.
b. Measure the panel thickness. The average cured ply thickness shall be within the tolerance specified in MS. Its coefficient of variation shall not exceed 2%.
c. C-scan the panels in accordance with paragraph 6.6.1.
d. All panels intended for mechanical testing shall be subjected to void and fiber volume determination as per 2564.

6.1.4 Tabs: The specimen should fail in the gauge length and in the specified failure modes. This may require the use of tabs. When tabs are used, the material, lay-up and thickness shall be such that specimen failure occurs in the gauge length and in the specified failure mode.

The cure cycle for tab bonding shall be such that the laminate's properties are not influenced. Use a paste adhesive that cures at room temperature, reference paragraph 6.7.4. The adhesive shall be approved by CACRC-QPG.

For specimens to be aged the adhesive between the tab and the specimen may be protected from moisture/fluid by sealing exposed glue line edges of the tab with silicone sealant or metal tape.

6.1.5 Specimen Machining: After machining, the fiber orientation shall be accurate within ±3°. Machined surface finishes and dimensional tolerances shall be maintained in accordance with the test method specification, and the specimens shall be free of defects. Do not overheat the specimens.

6.1.6 Specimen Selection: Specimens to be tested at a particular test condition shall be randomly selected from the panel.

6.1.7 Storage of Panels and Specimens: Moisture may diffuse into the composite during specimen manufacturing and storage. To prevent uncontrolled moisture uptake, the storage procedures, including conditions and times, are specified in Tables 2 and 3. The purpose is to limit the weight gain due to moisture; the moisture content shall be 0.20% (by weight) maximum. If the various time/temperature/humidity limits cannot be satisfied, it shall be proven that the moisture uptake has not exceeded 0.20% . This limit is applicable to specimens to be tested in the 'DRY'-condition and specimens which are to be fluid immersed.

6.1.8 Drying of Specimens: If there is any doubt about the moisture uptake in the specimens a traveller or spare specimen as applicable shall be dried to equilibrium at 70 °C ± 3 to determine the moisture content. The weight loss due to moisture shall be less than 0.20%. Specimens dried at 70 °C shall not be tested afterwards because the drying procedure may have given the material a post-cure.

When the moisture content exceeds 0.20% the remaining specimens shall be dried at 40 °C ± 2 to reduce the moisture content to less than 0.20%. No specimen shall be dried more than once.

6.1.9 Strain Gauge Bonding: Standard strain gauge bonding procedures can be used.

For fluid immersed or humidity aged specimens, bond the strain gauges after conditioning:

a. Remove the fluid from the surface of the specimen.
b. Wipe the bond area with a Methyl Ethyl Ketone (MEK) moistened cloth.
c. Apply the strain gauges.

6.2 Fluid Immersion and Humidity Aging:

6.2.1 Determination of Wet Conditioning Procedures: The initial wet conditioning procedure for laminates and cured neat resin is immersion in water because humidity aging is expected to give post cure effects. The screening test program, reference AMS 2980/2, specifies DMA tests on both water-immersed and humidity-aged neat resin specimens. Based on comparison of the DMA results, CACRC-QPG shall decide which wet conditioning procedure shall be selected for the qualification program.

Laminates shall be wet conditioned in accordance with paragraph 6.2.4 and EN 2823 for water immersion and humidity aging, respectively.

Sandwich panels shall be conditioned by humidity aging; see paragraph 6.2.5.

6.2.2 Traveller Specimens: Three traveller specimens shall be used for each of the following:

a. Combination of fluid type and laminate thickness to be conditioned, except for specimens to be solvent immersed
b. Laminate thickness to be humidity aged
c. Sandwich panel configuration to be humidity aged
d. Combination of material batches to be tested
e. Each set of panels or specimens that essentially follows different route and/or schedule

Traveller specimen dimensions:

a. For solid panels length and width both larger than 25 mm. Spare specimens may be used provided the specimens do not have tabs.
b. For sandwich panels length and width 50 mm ± 5. Traveller specimen edges shall be sealed, refer to paragraph 6.2.5.

Accuracy of weight gain measurement: 0.02% (absolute).

6.2.3 Selected Fluids: For assessment of the influence of fluids on the mechanical properties the following fluids shall be used; refer to EN 2379:

Water	: specification not applicable,	distilled water
Fuel	: EN 2379 test fuel 1,	JET A 1, NATO code F-34, Kerosene - Low freeze point
Solvent	: EN 2379 Methyl Ethyl Ketone,	Laboratory grade
Hydraulic fluid	: EN 2379 Tri-N-butyl phosphate ester,	Laboratory grade

TABLE 2 - Storage Conditions and Times for Laminate Panels and Laminate Specimens

Subsequent Steps in the Manufacturing Process	Specimen Test Condition[1]: Dry	Specimen Test Condition[1]: Solvent Immersed	Specimen Test Condition[1]: Fuel Immersed	Specimen Test Condition[1]: Hydraulic Fluid Immersed	Specimen Test Condition[1]: Wet (Water Immersed or Humidity Aged)
Panel, subpanel and specimen manufacturing	Record wet lay-up panel curing date. Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Permitted open time for manufacturing is 14 days at ambient condition (typically T≤28 °C and RH≤75%).	Record wet lay-up panel curing date. Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Permitted open time for manufacturing is 14 days at ambient condition (typically T≤28 °C and RH≤75%).	Record wet lay-up panel curing date. Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Permitted open time for manufacturing is 14 days at ambient condition (typically T≤28 °C and RH≤75%).	Record wet lay-up panel curing date. Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Permitted open time for manufacturing is 14 days at ambient condition (typically T≤28 °C and RH≤75%).	Record wet lay-up panel curing date. Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Permitted open time for manufacturing is 14 days at ambient condition (typically T≤28 °C and RH≤75%).
Specimen storage prior to fluid immersion	-	Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Storage time: max 14 weeks after the panel curing date[2] . Requirement: specimen moisture content ≤0.20% by weight[3].	Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Storage time: max 14 weeks after the panel curing date[2] . Requirement: specimen moisture content ≤0.20% by weight[3].	Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Storage time: max 14 weeks after the panel curing date[2] . Requirement: specimen moisture content ≤0.20% by weight[3].	Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Storage time: max 14 weeks after the panel curing date[2] . Requirement: specimen moisture content ≤0.20% by weight[3].
Aging or exposure	-	Immersion in solvent at room temp	Immersion in fuel at room temp	Immersion in hydraulic fluid at elevated temp	Aging in humidity chamber or immersion in water at elevated temp
Storage before testing	Storage at 23 °C ± 5 in moisture proof bag with desiccant. Storage time: max 22 weeks after the panel curing date[2]. Requirement: specimen moisture content ≤0.20% by weight[3].	No storage allowed	23 °C ± 5 in fuel bath, max time 8 hours	23 °C ± 5 in hydraulic fluid bath, max time 8 hours	Humidity aged: 23 °C ± 5 in wet towel. Water immersed: 23 °C ± 5 in water bath or wet towel. Max time 8 hours
Strain gauge bonding	Max 4 hours at ambient condition	Max 1 hour at ambient condition	Max 1 hour at ambient condition	Max 1 hour at ambient condition	Max 1 hour at ambient condition
Open time in test cabinet	Max 24 hours at 23 °C ± 2	Max 1 hour at 23 °C ± 2	Max 1 hour at 23 °C ± 2	Max 1 hour at 23 °C ± 2	Max 1 hour at 23 °C ± 2

[1] Fluids are specified in 6.1; aging conditions are specified in AMS 2980/2.
[2] Exceeding the time limit requires measurement of specimen moisture content; refer to 6.1.8.
[3] Exceeding the moisture limit requires drying of specimens; refer to 6.1.8.

TABLE 3 - Storage Conditions and Times for Sandwich Panels and Sandwich Specimens

Subsequent Steps in the Manufacturing Process	Specimen Test Condition[1]: Dry	Specimen Test Condition[1]: Wet (Humidity aged)
Panel and sub-panel manufacturing	Record wet lay-up panel curing date. Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Permitted open time for manufacturing, including specimen machining, is 14 days at ambient condition (typically T≤28 °C and RH≤75%).	Record wet lay-up panel curing date. Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Permitted open time for manufacturing, including specimen machining, is 14 days at ambient condition (typically T≤28 °C and RH≤75%).
Panel storage prior to aging	-	Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Storage time: max 14 weeks after the panel curing date[2]. Requirement: specimen moisture content ≤0.20% by weight[3].
Aging	-	Humidity chamber at specified temperature and humidity
Specimen machining	Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Permitted open time for manufacturing, including panel manufacturing, is 14 days at ambient condition (typically T≤28 °C and RH≤75%).	Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Permitted open time for manufacturing, including panel manufacturing, is 14 days at ambient condition (typically T≤28 °C and RH≤75%).
Storage before testing	Storage at 23 °C ± 5 in moisture-proof bag with desiccant. Storage time: max 22 weeks after the panel curing date[2] Requirement: specimen moisture content ≤0.20% by weight[3].	Storage at 23 °C ± 5 wrapped in a wet towel in a moisture proof bag. Max time 8 hours
Strain gauge bonding	Max 4 hours at ambient condition	Max 1 hour at ambient condition
Open time in test cabinet	Max 24 hours at 23 °C ± 2	Max 1 hour at 23 °C ± 2

[1] Humidity aging procedure is specified in 6.1; aging conditions are specified in AMS 2980/2.
[2] Exceeding the time limit requires measurement of specimen moisture content; refer to 6.1.8.
[3] Exceeding the moisture limit requires drying of specimens; refer to 6.1.8.

6.2.4 Fluid Immersion Procedure: The fluid immersion shall be performed in accordance with EN 2489 by total immersion of the specimens. The immersion temperature and period are specified in AMS 2980/2.

The following supplements EN 2489:

a. Use new fluid only.
b. When immersing specimens the fluid shall be at the required temperature.
c. During immersion fluid replacement is not required.
d. Determining fluid composition is not required.
e. Visual inspection of specimens is not required.
f. Determination of the weight gain: Wipe the traveller specimens with a paper towel or lint free cloth; determine the weight gain immediately after immersion.

6.2.5 Humidity Aging of Sandwich Panels: Age the sandwich panels before cutting into specimens. Seal the edges of the sandwich panels and the traveller specimens, e.g., with metal foil tape, to prevent moisture diffusion via the honeycomb core. Perform the humidity aging in accordance with EN 2823 except the aging conditions and period are specified in Table 3 and AMS 2980/2.

6.3 Report on Specimen Manufacturing, Conditioning and Storage:

The specimen manufacturing report shall refer to this standard and shall permit full traceability. Any incident which may have affected the quality of the specimen and any deviation from this specification shall be reported. The report shall include at least the following:

6.3.1 Panel Manufacturing: Report the complete identification of the materials to be tested, including material manufacturer identification, material characteristics (for fabric e.g. filament count, fiber areal weight, weave style), batch number, date of receipt, material receiving inspection and/or batch release report.

All details about manufacturing of the panels shall include at least:

a. Panel manufacturing date
b. Individuals performing the manufacturing
c. Shop temperature and humidity
d. Conditioning of the materials
e. Time table for mixing, impregnating and curing
f. Description of the specific lay-up of bleeding materials, breather material and the precise location of the thermocouples
g. Curing parameters, including the diagrams and equipment used
h. Cutting procedure/drying
i. C-scan results, settings and equipment used
j. Measured thickness

6.3.2 Specimen Manufacturing:

a. Report the tab material, lay-up and geometry, the adhesive and the cure cycle for tab bonding.
b. Report from which panel the specimens are cut. Report what equipment is used for cutting.
c. Report period of specimen storage and storage conditions. When the specimens have been dried, report the drying procedures and the weight reduction.

6.3.3 Fluid Immersion: In addition to the requirements in EN 2379 report:

a. Type of fluid
b. Fluid temperature
c. Immersion period (including dates)
d. Type of container
e. Dimensions of traveller specimens and the weight gain after immersion

6.3.4 Humidity Aging: Report the weight gain versus aging time.

6.4 Test Procedure for Testing at Nonambient Conditions:

6.4.1 Temperature Chamber: The temperature chamber, in combination with the test fixture and the specimen, shall be such that the gauge length of the specimen is at the required test temperature within the time specified below. The temperature chamber shall be approved by CACRC-QPG. The temperature measurement equipment shall be calibrated in accordance with ASTM E 4, accuracy 1 °C.

Usually the temperature is:

a. Controlled by one thermocouple measuring the air temperature in the chamber
b. Monitored by one thermocouple in the gauge length on the specimen, sealed from direct exposure to the air.

6.4.2 Testing at Elevated Temperatures: Before starting testing, the temperature chamber and the test fixture shall be pre-heated.

Each specimen mounted in the test fixture shall be heated to the required test temperature. The heat-up time of the specimen shall not exceed 5 minutes. The test shall start 2 minutes after the specimen has reached the test temperature. During the test, the temperature, as measured on the specimen, shall be the test temperature ±2 °C.

For specimens to be tested at 120 °C the following apply:

For each batch of material and for each laminate thickness to be tested at a temperature of 120 °C the moisture content after testing shall be determined on a traveller specimen. Determine from the mechanical test to be performed on that laminate thickness the longest time from closing the temperature chamber to specimen failure. Put the traveller specimen in a temperature chamber and simulate that temperature cycle. Report the measured moisture content prior to and after testing.

6.4.3 Testing at Sub-Zero Temperatures: Before starting testing, the temperature chamber and the test fixture shall be pre-cooled.

Each specimen mounted in the test fixture shall be cooled to the required test temperature. The test shall start 5 minutes after the specimen has reached the test temperature. During the test, the temperature, as measured on the specimen, shall be the test temperature ±2 °C.

6.5 Additions and Changes to Standard Test Methods:

All tests required for qualification shall be performed in accordance with the Standard Test Methods specified in AMS 2980/1 and AMS 2980/2 including any changes or additions defined in AMS 2980/1.

If two or more alternate test methods are specified for a test the qualifier shall select a test method from those specified.

a. All requirements of the selected test method including changes or additions as specified in AMS 2980/1 are mandatory. It is not permissible to mix requirements of the alternate test methods.
b. Changes and additions specified in AMS 2980/1 for each test type are mandatory for all alternate test methods for that test type unless a specific exception has been specified.
c. Requirements of the Material Specification are valid for all test methods unless a specific exception has been defined.

The IPS of a qualified material combination will define the test methods which were used for qualification testing and those to be used for batch release testing of the qualified material.

6.5.1 General:

6.5.1.1 Unit to be Used: The test results shall be reported in both SI and imperial units. The following units shall be used respectively:

Strains : µmm/mm µinch/inch
Stresses : MPa psi
Moduli : GPa ksi
Dimensions : mm inch

6.5.1.2 Test Equipment: All equipment shall be calibrated. Alignment of equipment shall be verified with suitable methods prior to tests like back to back strain measurement on dummy specimen.

6.5.1.3 Measurement Equipment: Micrometers for thickness measurements shall have ball/ball interfaces or at least a ball interface on the side to measure rough surfaces (non tool side).

Vernier calliper or equivalent shall be used.

6.5.1.4 Strain Measurement: Strain measurement shall be accurate to within 1% of the measured value at both the specified strain level and at the failure strain. Either strain gauge(s) or extensometer(s) may be used. Report strain gauge type and length or extensometer gauge length.

6.5.1.5 Failure Mode: Each test has (a) specific failure mode(s). Every specimen should have failed in the specified failure mode(s). Actual test failure modes shall be reported.

The test data of specimen that did not fail in one of the specified failure modes shall be submitted to CACRC-QPG for review.

6.5.1.6 Test Procedure: Prior to testing, fluid immersed specimens shall be wiped with a paper towel or lint free cloth.

Unless otherwise indicated in the changes and additions applicable to the specific test method:

a. Number of specimens to be tested per test condition is defined in AMS 2980/2.
b. The nominal laminate thickness shall be used in calculations of stress, strength, and modulus. The nominal laminate thickness is the number of plies times the nominal ply thickness. The nominal ply thickness is specified in the MS.
c. Fibre volume measurements are not required for normalisation purposes, but only for quality control and void volume determination (Refer to AMS 2980/2).
d. Use the measured specimen width determined in accordance with the procedure defined in the actual test method in calculations where this measurement is required.
e. Report failure loads and actual specimen dimensions.
f. Modulus determinations shall be performed according to the secant method of the relevant stress-strain curve.

6.5.1.7 Application of Test Results: Application of test results is the responsibility of the user.

6.5.2 Tensile Weft: Reference specifications: EN 2561-C or ASTM D 3039/ASTM D 3039M.

6.5.2.1 Specific Additions and Changes:

a. Laminate lay-up: see AMS 2980/2
b. Overall specimen length: 250 mm ± 3
c. Specimen width: 25 mm ± 0.25 measured on three locations along the gauge length
d. Gauge length: ≥125 mm
e. Side to side parallelism: 0.08 mm
f. Face to face parallelism: 0.08 mm
g. The use of tabs shall be optional, to be agreed between the parties involved in the individual qualification. Tab definition: EN 2561-A or ASTM D 3039/ASTM D 3039M
h. Modulus reference points: 1000 and 3000 μmm/mm
i. Failure strain shall be measured
j. Poisson's ratio shall be determined if specified in AMS 2980/2
k. Specified failure modes: Tension failure within the gauge length lateral or angle direction

6.5.3 Compressive Weft: Reference specification: EN 2850-B.

6.5.3.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 2980/2
b. Gauge length: 12.5 mm ± 0.2
c. To verify alignment and specimen load response back to back strain gauge measurements shall be obtained on the first specimen for each test condition
d. Modulus reference points: 1000 and 3000 μmm/mm
e. Test fixture use: First torque all bolts sequentially to a low torque, then increase sequentially to the specified torque
f. Specified failure modes: Compression failure within the gauge length including through thickness shear, brooming, transverse shear or splitting

6.5.4 Tensile In-Plane Shear (±45°): Reference specifications: EN 6031 or ASTM D 3518/3518M.

6.5.4.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 2980/2
b. Overall specimen length: 230 mm ± 1
c. Specimen width: 25 mm ± 0.25 measured on three locations along the gauge length
d. Thickness tolerance: ±0.2 mm
e. Side to side parallelism: 0.08 mm
f. Face to face parallelism: 0.08 mm
g. Cross head speed: 2.0 mm/min or 0.1 inch/min
h. Stress of each specimen shall be determined at:
   (1) 0.2% offset shear strain
   (2) 5% shear strain
   (3) ultimate
i. Modulus reference points: 2000 and 6000 shear strain
j. All stresses and moduli shall be calculated and reported with both the average measured laminate thickness and the nominal laminate thickness
k. Specified failure mode: No tension or shear failure before defined strain levels. Ultimate shall fail within the gauge length.

6.5.5 DMA Composite: Reference specifications: EN 6032-A or ASTM E 1640.

6.5.5.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 2980/2
b. Specimen length and width: According to requirements of the test equipment
c. Start temperature: Room temperature
d. Loading mode: To be reported
e. Strain range: Within linear viscoelastic range, <1000 microstrain recommended. Actual range to be reported.
f. Heating rate: 5.0 °C ± 0.2
g. Purge gas and flow rate: To be reported
h. Transducers and controllers: To be reported
i. Individual results of each specimen to be reported
j. Test data: Storage modulus at 23 °C, 80 °C and 120 °C, no Tg, etc.
k. Reported data: Percentage of change in storage modulus at 80 °C and 120 °C compared to that at 23 °C
l. Plot scale presentation: Linear and log scale

6.5.6 Tensile QI: Reference specifications: EN 6035-A or ASTM D 3039/ASTM D 3039M.

6.5.6.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 2980/2
b. Specimen EN 6035-A: According to Figure 1 of EN 6035-A without hole
c. Gauge length: 180 mm minimum
d. Specimen width: 38.1 mm ± 0.1
e. Side to side parallelism: 0.08 mm
f. Face to face parallelism: 0.08 mm
g. The use of tabs shall be optional, to be agreed between parties involved in an actual qualification
h. Cross head speed: 2 mm/min or 0.05 inch/min
i. Measure and report Young's modulus and failure strain
j. Modulus reference points: 1000 and 3000 µmm/mm
k. Specified failure mode: Any tension failure within the gauge length

6.5.7 Tensile QI Open-Hole: Reference specifications: EN 6035-A or ASTM D 5766/D 5766M.

6.5.7.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 2980/2
b. Gauge length: 180 mm minimum
c. Specimen width: 38.1 mm ± 0.1
d. Hole diameter: 6.35 mm +0.09/-0
e. Hole centerline tolerance: ±0.1 mm
f. Hole micrometer: Type as required with an accuracy of ±0.025 mm
g. Cross head speed: 2 mm/min or 0.05 inch/min
h. Report failure stress and width to hole diameter ratio (w/d)
i. Specified failure mode: Any tension failure through the hole

6.5.8 Compressive QI: Reference specification: SACMA SRM 3 issue 1994.

6.5.8.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 2980/2
b. Specimen: Without circular hole
c. Cross head speed: 1 mm/min or 0.05 inch/min
d. Modulus reference points: 1000 and 3000 μmm/mm
e. Failure strain: To be reported
f. Specified failure modes: Compression failure within the gauge length including through thickness shear, brooming or transverse shear

6.5.9 Compressive QI Open-Hole: Reference specification: SACMA SRM 3 issue 1994.

6.5.9.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 2980/2
b. Specimen hole diameter: 6.35 mm +0.09/-0
c. Measurements: Hole diameter and specimen width at the location of the hole
d. Cross head speed: 1 mm/min or 0.05 inch/min
e. Failure stress: To be reported only, no modulus
f. Specified failure mode: Any compression failure through the hole

6.5.10 Bearing QI: Reference specification: EN 6037-A.

6.5.10.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 2980/2

6.5.11 Compression After Impact: Reference specification: EN 6038.

6.5.11.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 2980/2
b. Impactor roughness: Ra <0.8 μm
c. Number of impact energy levels to be tested in compression: 3 levels determined in accordance with paragraph 6.5.11.2
d. Energy level tolerance: ±10%
e. Impact indentation depths of all specimens to be determined and reported
f. Visible damages shall be recorded on both sides of the specimens
g. Post impact NDI inspection: Similar to pre impact inspection on at least one representative specimen of each impact level determined for compression testing
h. Cross head speed: 1 mm/min
i. Strain gauges shall be applied to both sides of the specimen and coupled to the recorder such that panel buckling can be detected
j. Specified failure mode: Compression failure including at least a portion of the impacted area

6.5.11.2 Determination of the Impact Levels to be Tested: A series of impacts shall be performed to determine the impact energy which gives an indentation depth of 0.3 mm on the impacted surface; damage at the other surface is not of interest in this definition.

The specimen(s) used in this part of the test method will not be tested in compression; therefore the specimen dimension may be equal or greater than the specimens used to determine the failure load. All impacts may be done on one specimen if possible. It is assumed that the impacts do not interact. If the back face of the specimen shows considerable damage (e.g., fiber splitting) due to repeated impacts, a second specimen shall be used to confirm the indentation depth.

Test procedure: Preselected levels of impact are specified in the referenced test method. Impact the specimen with lowest preselected level. Measure the indentation depth. If the depth is smaller than 0.3 mm, impact this specimen on another location, with the next higher impact level. Repeat this procedure until an indentation depth of □0.3 mm is found. The last impact level tested is defined as the 0.3 mm impact energy level.

From above test procedure, three impact energy levels shall be determined for compression testing:

1. The impact energy that gives 0.3 mm indentation
2. One level below the 0.3 mm impact energy level
3. Two levels above the 0.3 mm impact energy level

If this level exceeds the preselected impact levels specified in the referenced test method, CACRC-QPG will define the upper impact energy level

6.5.12 Flatwise Tensile: Reference specifications: EN 6062 or ASTM C 297.

6.5.12.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 2980/2. 0°-direction parallel to ribbon direction of the honeycomb
b. Geometry: Square 50 x 50 mm ± 0.5 for specimen and facing blocks
c. Specimen manufacturing: According to paragraph 6.7.8 using Aramid paper based phenolic honeycomb referenced in AMS 2980/2
d. Facing block material: Al 2024-T351, 25 mm thick
e. Bonding of aluminum facing blocks: See paragraph 6.5.12.2
f. Specified failure mode: Bondline of the repair skin to the honeycomb

6.5.12.2 Bonding of Aluminum Facing Blocks: The cure cycle shall be such that the laminate properties are not altered.. The selected adhesive shall be approved by CACRC-QPG, see paragraph 6.7.4 for suggested material.

6.5.13 Long Beam Sandwich Flexure: Reference specifications: EN 6061 or ASTM C 393.

6.5.13.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 2980/2
b. Load span: 100 mm
c. Support span: 560 mm ± 1
d. Loading cylinders: Diameter 15 mm, circular within 1% of diameter and straight within 0.5% of the length
e. Support cylinders: Diameter 30 mm, circular within 1% of diameter and straight within 0.5% of the length
f. Specimen manufacturing: According to paragraph 6.7.8
g. Specimen width: 75.0 mm ± 0.1
h. Specimen length: 610 mm ± 1
i. Specimen position for testing: Wet lay-up skin in compression
j. Specified failure mode: Compression failure of the wet lay-up skin or debonding of the honeycomb core and the wet lay-up skin in the area inside of the loading span
k. Deflection: No measurement required

6.5.14 Tensile Tapered Joint: Reference specification: EN 6066.

6.5.14.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 2980/2
b. Laminate manufacturing: See paragraph 6.7.9 or 6.7.10 as applicable
c. Joint length: 80 mm

6.5.15 Tensile Stepped Joint: Reference specification: EN 6066.

6.5.15.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 2980/2
b. Laminate manufacturing: See paragraph 6.7.9
c. Joint length: 75 mm

6.6 Determination of Laminate Quality:

6.6.1 C-Scan: The panel quality and its suitability for mechanical testing shall be determined with ultrasonic inspection. Objectives of the inspections are specified in the following paragraphs. Subsequently example inspection techniques are mentioned. The lay-up of the panels is specified in AMS 2980/2.

6.6.1.1 Laminate Panels: For laminate panels the inspection shall be suitable to:

a. detect delaminations
b. determine the homogeneity of the panel with respect to porosity
c. determine the average attenuation

The quality of the individual laminate panels, manufactured with the same procedure, shall be compared. Acceptance and rejection criteria will be determined by CACRC-QPG.

6.6.1.2 Sandwich Panels: For sandwich panels the inspection shall be suitable to:

a. detect delaminations
b. detect core skin disbonds

Acceptance and rejection criteria will be determined by CACRC-QPG.

6.6.1.3 Procedure: Inspection equipment, procedures, equipment settings and the qualification of the scan-operator shall be agreed upon between the manufacture and CACRC-QPG. Example methods and equipment settings are described below.

Example method for inspection of laminate panels:

Method	immersion through transmission
Frequency	5 MHz broad band
Focus	spot (spherical), focal distance 61 mm
Beam width at -6 dB	1 mm maximum
Distance between transducers	2 times focal distance

Example method for inspection of sandwich panels:

Method	water jet through transmission
Frequency	1 MHz
Squirter diameter	6 mm
Distance between transducers	as small as possible

Example for scan parameters:

Scan parameters	step size in both scan and index direction 1 mm
Distances	product is placed in the center between the transducers
Instrument	damping (serial in transmitter) 50 ohm frequency range on broad band
System	computerized system with digital data acquisition and post processing capabilities; system linearity ±2% maximum

6.6.2 Void Content: The panel lay-up is specified in AMS 2980/2.

The procedure to determine laminate porosity is as follows:

1. Obtain five specimens from different areas of the panel. Specimens should be approximately 50 mm (2 inches) long.
2. Polish to zero scratches. The polishing step is critical. Any surface scratches will adversely affect the porosity reading. Do not contaminate the surface to be polished with mounting compound.
3. Perform image analysis:
   a. Use either microscope or SEM connected to an image analyzer. The report shall indicate the equipment used.
   b. Magnify the image to 50 X.
   c. Use the computer to obtain an image of the part, or section being analyzed. Digitize the image into shades of grey.
   d. Determine critical grey level; darker levels are porosity, lighter are not.
   e. Mark porosity.
   f. Ratio the percent porosity to total area of the image.
   g. The image readings shall cover the entire area of laminate coupons, or of the skins of sandwich coupons.
   h. Use 20 readings of each specimen.
   i. Tight scatter indicates a uniform panel. Wide scatter indicates variable porosity in the panel and additional image analysis should be performed (on more specimens).

6.7 Specimen Manufacturing:

6.7.1 General:

Personnel - Only sufficiently trained and competent personnel shall perform the laminating, curing and machining work.

Health and safety - This standard does not provide any directions necessary to meet health and safety requirements. It is the responsibility of the user of this standard to consult and establish appropriate health and safety precautions in accordance with relevant local laws.

Shop conditions - Unless otherwise specified, the conditions of the laminating shop shall be:

Temperature : 15 to 30 °C
Relative Humidity : 30 to 75%

6.7.2 Equipment:

Balance: Balance with an accuracy of 0.01 gram.

Control and recording devices: Suitable devices to control and record temperature of the laminate and vacuum pressure. Record these parameters over time.

Accuracy: Temperature : ±2%.
Vacuum : ±15%.

Cutting equipment: Equipment for sawing or machining shall be capable of achieving the dimensional tolerances defined for the specimens.

The machining speed shall be such that the local temperature of the specimen shall not exceed 60 °C during the cutting operation.

The process may be performed in dry or wet condition. Wet condition is recommended to lower the cutting temperature and to avoid carbon dust. To cool the specimen, water without additives, shall be used.

Heat sources to assist squeeze-out operation: Iron, heat gun, or heat table with adjustable temperature to control the laminate temperature to 35 °C maximum may be used to assist the squeeze-out operation.

Oven: Air circulating oven shall be of suitable size to maintain temperature and heat-up rate in the necessary ranges in accordance with material requirements. The oven shall allow continuous vacuum application during cure. Care shall be taken to ensure that the oven used to cure composite panels is never used for processes which might cause contamination, e.g., drying of release agents. The use of other heat sources shall be approved by CACRC-QPG.

Thermocouples: The laminate temperature shall be measured with thermocouples.

Commercially available welded thermocouples may be used.

Vacuum pump: Vacuum pump of suitable capacity and performance to maintain a constant vacuum pressure under the bag of 75 kPa minimum during the entire curing process shall be used.

6.7.3 Essential Expendable Materials: In general all essential expendable materials shall be tested before first use. They shall fulfill the following requirements:

a. No contamination of the laminate
b. Resistant to the uncured resin components (solvents, etc.)
c. No outgassing at elevated temperatures
d. No water absorption during storage.

The following material shall be used:

a. Beaker of suitable size and material to mix the base resin and curing agent. Recommended material: polypropylene.
b. Woven glass fiber fabrics, US - 120 style with an areal weight of 100 g/m2. This glass fabric shall be used as bleeder material for vertical bleeding. It can also be used as breather material.
c. Spatula to blend the resin and curing agent. Recommended material: Polyamide or polyethylene.
d. Standard nonperforated release films like polyvinyl fluoride (PVF) or polytetrafluoroethylene (PTFE).

The parting film shall be used as foil on the tool plate and as a separation foil between bleeder and breather in the vertical bleeding process.

NOTE: The use of colored film helps to minimize the risk of not removing the film during ply lay-up.

e. Standard perforated parting film like polyvinylfluoride (PVF) or polytetrafluoroethylene (PTFE) with hole diameters of approximately 1-1.2 mm and open area of 1.25-2.25%. The perforated film is used in the bagging procedure for vertical bleeding process.
f. Polyamide fiber fabric peel ply with an areal weight of 60 g/m2. Requirements:
   (1) No impregnation with any release agent or other agent detrimental to bonding is allowed.
   (2) For squeeze out the peel ply is used for detection of remaining entrapped air. No specific absorbing capacity is required for this purpose.
g. Standard release agent of the nonsilicone type.