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INTERNATIONAL
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AEROSPACE MATERIAL SPECIFICATION

SAE AMS 3970/1

Issued DEC 1999

Submitted for recognition as an American National Standard

Carbon Fiber Fabric Repair Prepreg, 125 °C (250 °F) Vacuum Curing
Part 1 - General Requirements

FOREWORD

AMS 3970/1 belongs to the Technical Specification system explained in AMS 3970.

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1. SCOPE:

AMS 3970/1 gives information about the technical requirements and qualification procedure for carbon fiber fabric epoxy prepreg used for repair of carbon fiber reinforced epoxy structures. The prepreg system may include a film adhesive to be applied in a co-curing process with the prepreg for joint and sandwich bonding. The need for a film adhesive shall be established during screening tests.

2. REFERENCES:

The following publications form a part of this specification to the extent specified herein. The latest issue of the SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order unless otherwise specified.

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001

AMS 3970 Carbon Fiber Fabric Repair Prepreg, 125 °C (250 °F) Vacuum Curing – Part 0 - Introduction
AMS 3970/2 Carbon Fiber Fabric Repair Prepreg, 125 °C (250 °F) Vacuum Curing - Part 2 - Qualification Program for Fiber, Fabric, Resin and Film Adhesive
AIR 4844 Composite 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, West Conshohocken, PA 19428-2959

ASTM C 297	Standard Test Method for Flatwise Tensile Strength of Sandwich Constructions.
ASTM C 393	Standard Test Method for Flexural Properties of Sandwich Constructions.
ASTM D 1002	Standard Test Method for Apparent Strength of Single-Lap-Joint Adhesively Bonded Metal Specimens by Tension Loading (Metal-to-Metal).
ASTM D 3039/D 3039M	Standard Test Method for Tensile Properties of Polymer Matrix Composite Materials.
ASTM D 3518/D 3518M	Standard Practice for In-Plane Shear Response of Polymer Matrix Composite Materials by Tensile Test of a ±45° Laminate.
ASTM D 3532	Standard Test Method for Gel Time of Carbon Fiber-Epoxy Prepreg.
ASTM D 3990	Standard Terminology Relating to Fabric Defects.
ASTM D 4440	Standard Practice for Rheological Measurement of Polymer Melts using Dynamic Mechanical Procedures.
ASTM D 5766/D 5766M	Standard Test Method for Open Hole Tensile Strength of Polymer Matrix Composite Laminates.
ASTM E 4	Standard Practices for Force Verification of Testing Machines.
ASTM E 1252	Standard Practice for General Techniques for Qualitative Infrared Analysis.
ASTM E 1640	Standard Test Method for Assignment of the Glass Transition Temperature By Dynamic Mechanical Analysis

2.3 EN Publications:

Available from CEN-comite, Europeen de Normalisation, Secretatiat Central, Rue de Stassart 36, B-1050 Bruxelles, Belgium

EN 2243-6	Aerospace Series: Structural Adhesives Test Methods. Part 6: Determination of shear stress and shear strain
EN 2243-7	Aerospace Series: Structural Adhesives Test Methods. Part 7: Determination of the flow characteristics of a film adhesive
EN 2379	Aerospace Series: Test fluids for non metallic materials
EN 2489	Aerospace Series: Fiber reinforced plastics - Determination of the Action of Liquid Chemicals
EN 2557	Aerospace Series: Carbon fibre preimpregnates, Test method for the determination of mass per unit area
EN 2558	Aerospace Series: Carbon fibre preimpregnates, Test method for the determination of the percentage of volatile matter
EN 2559	Aerospace Series: Carbon fibre preimpregnates, Test method for the determination of the resin and fibre content and the mass of fibre per unit area
EN 2560	Aerospace Series: Carbon fibre preimpregnates, Test method for the determination of the resin flow

2.3 (Continued):

EN 2561	Aerospace Series: Unidirectional laminates - Carbon thermosetting resin, Tensile test parallel to the fiber direction
EN 2564	Aerospace Series: Carbon fiber laminates - Test method for the determination of the fiber and resin fraction and porosity content
EN 2565	Aerospace Series: Preparation of carbon fiber reinforced resin panels for test purposes
EN 2823	Aerospace Series: Fiber reinforced plastic, Test method for the determination of the effect of exposure to humid atmospheres on physical and mechanical characteristics
EN 2850	Aerospace Series: Fiber reinforced plastics, Testing unidirectional laminates and woven fabric laminates - Compression test
EN 3003	Aerospace Series: Test method - Determination of mass per unit area of film adhesives
EN 3615	Aerospace Series: Fiber reinforced plastics, Procedure for the determination of the conditions of exposure to humid atmosphere and the determination of moisture absorption
EN 6031	Aerospace Series: Fiber reinforced plastic, Determination of in-plane shear properties (±45° Tensile test)
EN 6032	Aerospace Series: Determination of glass transition temperature (DMA).
EN 6033	Aerospace Series: Carbon fiber reinforced plastics, Determination of the interlaminar fracture toughness energy - Mode I - G1c Test
EN 6034	Aerospace Series: Carbon fiber reinforced plastics, Determination of the interlaminar fracture toughness energy - Mode II - G2c Test
EN 6035	Aerospace Series: Fiber reinforced plastics, Determination of notched and unnotched tensile strength
EN 6037	Aerospace Series: Fiber reinforced plastics, Determination of bearing strength
EN 6038	Aerospace Series: Fiber reinforced plastic, Determination of compression strength after impact
EN 6040	Aerospace Series: Analysis of non-metallic materials (uncured) by high performance liquid chromatography (HPLC)
EN 6041	Aerospace Series: Analysis of non-metallic materials (uncured) by differential scanning calorimetry (DSC)
EN 6042	Aerospace Series: Analysis of organic compounds by infrared spectroscopy
EN 6043	Aerospace Series: Fiber reinforced plastics, Determination of gel time and viscosity
EN 6060	Aerospace Series: Fiber reinforced plastics, Tensile lap shear test
EN 6061	Aerospace Series: Fiber reinforced plastics, Sandwich flexural test 4 point bending
EN 6062	Aerospace Series: Fiber reinforced plastics, Flatwise tensile test of composite sandwich panel
EN 6064	Aerospace Series: Analysis of non-metallic materials (cured) for the determination of the extent of cure by DSC
EN 6066	Aerospace Series: Fiber reinforced plastics, Determination of stepped and tapered joint strength

2.4 ISO Publications:

Available from ISO, Central Secretariat, 1 Rue de Varembe, Case Postale 56, CH-1211 Geneve 20, Switzerland

ISO 472	Plastics – Vocabulary
ISO 1183	Density and Relative Density of Non-Cellular Plastics
ISO 1890	Carbon Fiber - Determination of Twist
ISO 10119	Carbon Fiber - Determination of Density
ISO 10120	Carbon Fiber - Determination of Linear Density
ISO 10548	Carbon Fiber - Determination of Size Content
ISO 10618	Carbon Fiber - Determination of Tensile Properties by Resin Impregnated Yarn Specimens

2.5 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 specification, the definitions in ISO 472 apply with the following additions or modifications. For further definitions or explanations of terms, refer to AIR 4844.

3.2 Specific for Carbon Fiber Prepreg and Film Adhesive:

FILM ADHESIVE: Semi finished product of specified areal weight produced from thermosetting resin in an uncured state of certain advancement, ready to be applied in bondlines for co-curing with a prepreg. A suitable carrier material (fabric or scrim) shall be incorporated into the film adhesive to improve handleability and to define minimum bondline thickness.

FILM ADHESIVE BATCH: A film adhesive batch is produced in one continuous manufacturing operation that conforms to a fixed manufacturing process in accordance with the process control document (PCD) using one batch of resin and suitable carrier with traceability to the individual batches of resin and carrier used. A continuous manufacturing operation is defined as one in which the process is not interrupted for more than 72 continuous hours, during which time the materials shall be stored according to the certified production procedure. Any interruption shall not contain a different product run. The total production time, interruptions included, shall not exceed five days unless otherwise stated in the relevant Individual Production Sheet (IPS).

ADHESIVE ROLL: Adhesive material including suitable protection foil(s) according to the PCD contained on one support tube.

3.2 (Continued):

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 from 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 a 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.

PREPREG: Semi finished product of woven fabric material impregnated with a specified amount of thermosetting resin in an uncured state of certain advancement ready for lamination and to be cured by heat and vacuum pressure only.

PREPREG SYSTEM: Prepreg material produced under a specific trade name by a prepreg manufacturer. In most cases a film adhesive is required for use with the prepreg for co-cure joint and sandwich bonding. The prepreg material and associated co-curing film adhesive are defined as the Prepreg System. It shall be responsibility of the prepreg manufacturer to select the appropriate film adhesive for the system.

PREPREG BATCH: A batch of preimpregnated fabric is produced in one continuous manufacturing operation using one batch of resin and one or several batches of dry fabric, with traceability to the individual batches of fabric used. These batches shall be constituted from the same type of fabric, supplied by the same weaver. A continuous manufacturing operation is defined as one in which the process is not interrupted for more than 72 continuous hours, during which time the materials shall be stored according to the certified production procedure. Any interruption shall not contain a different product run. The total production time, interruptions included, shall not exceed five days unless otherwise stated in the relevant IPS.

PREPREG ROLL: Prepreg material including suitable protection foil(s) according to the PCD contained on one support tube.

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.

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

3.2 (Continued):

RESIN BATCH: A quantity of homogeneous resin prepared in one operation with traceability to individual component batches as described in the PCD of the prepreg and adhesive manufacturer used to manufacture prepreg or film adhesive in accordance with the defined process. A resin batch may contain up to 15% of another approved and within shelf-life resin batch of the same resin type, blended uniformly with the major resin batch. Full traceability shall be maintained for all raw material constituents. The blended resin batch shall have a single new batch number.

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 Process Control Document: Prior to manufacturing the first qualification fiber, fabric, resin, prepreg or film adhesive batch, the manufacturer shall have established the PCD. The PCD shall be presented to PRI upon request. The PRI 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 PRI. Such changes may require a side qualification program. The batch release test report for the first delivery made after any change to the PCD shall contain a reference to the change.

4.1.2 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.

4.1.3 Health and Safety Requirements: The delivered prepreg and adhesive 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 prepreg and film adhesive 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 about the safe handling procedures of the material. The resin system formulation of the prepreg and film adhesive given to the PRI during qualification shall also be inspected for health and safety requirements.

4.1.4 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 himself to supply the qualified material for a minimum of 10 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.

4.1.5 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 AMS 3970/1 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 4.2.1. Looms used to weave fabrics for the repair prepreg 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 (case 3:1). Alternatively, if one batch is used in the warp direction, no more than three batches shall be used in weft direction (case 1:3). 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. The weaver shall assign numbers in consecutive order as the fabric is woven. Roll number assignment may be done:

a. at the time of weaving or
b. 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 includes selvage, shall be agreed upon between the manufacturer and prepreg manufacturer. The width tolerance shall be ±12.5 mm for each meter of fabric width.

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 each end of the roll. Material splicing deviations shall be allowed when agreed between purchaser and prepreg manufacturer.

Each fabric 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.

Further requirements with respect to fabric quality, defects, storage, etc. shall be agreed in a bilateral specification between the prepreg manufacturer and the fabric manufacturer to fulfill the relevant requirements of AMS 3970/1 as defined for the prepreg. The woven fabric shall meet the requirements of the MS when tested in accordance with AMS 3970/2.

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 defect 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 missing pick, missing end, whipped in weft, loose pick, slab, kink, or 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.

4.2.2.3 (Continued):

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 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.

4.2.3 Technical Requirements for Resin:

4.2.3.1 Resin Requirements: The resin used to manufacture the prepreg and film adhesive shall be an epoxy or modified epoxy type produced in accordance with AMS 3970/1 and meeting the requirements of the MS. The prepreg and film adhesive do not need to use the same epoxy system but must be compatible.

4.2.4 Technical Requirements for Prepreg:

4.2.4.1 Prepreg Requirements: Fabric prepreg shall be produced from woven fabric and resin meeting the requirements of 4.2.2 and 4.2.3. The prepreg shall meet the requirements of the MS when tested in accordance with AMS 3970/2.

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

The prepreg edges shall be straight and parallel to the warp direction. The selvage shall not show a resin rim greater than 1.2 mm unless otherwise agreed with the purchaser.

Carbon fabric in the prepreg 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 each end of the roll. Material splicing deviations shall be allowed when agreed between purchaser and prepreg manufacturer.

The warp yarns shall be aligned and run parallel to the prepreg edges; the weft yarns shall be perpendicular to them. The maximum allowable deviation from the straight reference line shall be:

- in warp direction 5 mm per 1 m of useable fabric length

- in weft direction 50 mm per 1 m of useable fabric width

Splices of adjacent yarns shall be spaced apart 12.5 mm minimum. A prepreg roll shall contain no more than one splice across the prepreg width.

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.

4.2.4.1 (Continued):

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 missing pick, missing end, whipped in weft, loose pick, slab, kink, fuzz ball shall be considered a continuous defect, if they involve more than one yarn.

4.2.5 Technical Requirements for Film Adhesive:

4.2.5.1 Film Adhesive Requirements: The film adhesive shall be produced from an epoxy or modified epoxy resin produced in accordance with the TS and meeting the requirements of the MS.

The film adhesive shall have cut edges ensuring presence of the carrier over the full width. Cutting tolerance of the width defined in the IPS or purchase order shall be ±1 mm.

4.2.6 Common Technical Requirements for Prepreg and Film Adhesive:

4.2.6.1 Release Film Material: The prepreg and the film adhesive shall be protected from contamination and, if necessary, from self adhesion by release film on one side or both sides. Films shall be removable easily from the prepreg or film adhesive without transfer of release materials or otherwise affecting the quality under shop conditions of 15 to 30 °C and 25 to 75% relative humidity. Different shop condition limits may be established in the IPS.

The release film shall be of a contrasting color and maintain its release and noncontaminative properties over a temperature range of –20 to +30 °C and a range of 25 to 75% relative humidity, if not otherwise agreed in the IPS. Release film material shall not protrude over the edges of the prepreg or adhesive material.

4.2.6.2 Material Requirements: Resin distribution and areal weight of the prepreg or the film adhesive shall comply in each area with the requirements of the MS. Visual resin starved or resin rich areas shall be considered as defects.

The prepreg and the film adhesive shall be of homogenous color and shall be free from foreign substances and undissolved (except by design) or cured resin system particles.

Creases, cuts and cracks are not permitted.

The formation of folds after unrolling the prepreg or the film adhesive shall not result in separation of the material from the release film.

4.2.6.3 Defects: Any defects in excess of that defined shall be cause for rejection of the specific material delivery or roll, according to the following requirements:

A defective area is the length of the defect, if that defect exceeds specified limits, multiplied by the roll width.

Defective areas are not part of the delivered quantity and shall not be included in the cost of the material.

The cumulative defective area in a roll shall not exceed 10% of the roll area.

All defects within a length of one linear meter are counted as one defective area.

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

Each defect shall be identified and flagged with a colored mark positioned on the roll.

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 type, location and length of each defect (if any) in that roll. As far as applicable definition of defect description terms shall be in accordance with ASTM D 3990. Defects not recorded by the manufacturer and detected by the user during application of the material shall be handled similar to recorded defects.

4.2.6.4 Storage Conditions: The prepreg and film adhesive rolls shall be stored in sealed moisture-proof bags in a clean and dry area. The prepreg or film adhesive rolls 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.

4.2.6.5 Storage Life: The prepreg and the film adhesive shall be capable of meeting the qualification requirements of this specification when stored in accordance with 4.2.6.4 at the temperature recommended by the manufacturer at least for the time specified in the MS. The minimum acceptable storage temperature is -18 °C. Storage life shall start from the day of receipt at the purchaser, unless otherwise agreed in the purchase documents. The Actual storage life of a product and storage life extension procedures may be described in the IPS.

4.2.6.6 Shelf Life: The shelf life of the prepreg and film adhesive after reaching ambient temperature shall be such that the material will meet the qualification requirements of this specification after exposure to extreme shop conditions of +30 °C and 75% relative humidity for a continuous or accumulative period as specified in the MS. Procedures for shelf life extension may be described in the IPS.

4.2.6.7 Processing Requirements: The following processing requirements shall be met by the prepreg system, unless exceptions have been specified in the IPS:

a. The prepreg system shall be capable of producing laminates, joints and honeycomb sandwich structure conforming to the requirements of this specification using vacuum as the sole means of consolidation.
b. A postcure of the cured laminate to attain the specification properties shall not be required.
c. Vacuum may be applied during the curing process at any time between room temperature and commencement of resin flow without altering the mechanical properties of the composite.
d. The viscosity of the resins during the curing process shall fulfill the requirements of the relevant MS.
e. The prepreg system shall be suitable for manufacturing laminates up to a thickness of 25 mm using the nominal cure cycle, without affecting the laminate quality due to exothermic reaction.
f. The tack of the prepreg and film adhesive shall be such that at shop conditions of 15 to 30 °C and 25 to 75% relative humidity the individual layers stick together when laminated without the use of heat, and adhere to the tooling surface (metal, plastic, foil etc.) even when draped during lay-up. Specified tack test requirements may be agreed between the manufacturer and the purchaser.

4.3 Requirements for Composite Materials:

The performance level of the composite material, achieved in the qualification testing as specified in AMS 3970/2, shall meet the values specified in the MS when subjected to a statistical method approved by the PRI (See 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 number of test specimens is listed in AMS 3970/2.

4.4.2 Test Methods for Fiber: Test methods for the fiber properties are listed in AMS 3970/2. These test methods shall be used unless written approval is given by the PRI 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 listed in the AMS 3970/2.

4.4.3.1 Fiber Areal Mass: The fiber areal mass shall be determined by weighing a 100 mm x 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 counting the yarns in both the warp and weft directions on three separate sample areas of minimum 100 mm x 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: The test methods accepted for characterization of the resin system of the prepreg and film adhesive are defined in AMS 3970/2.

Since the chemical composition of the resin systems under test are 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 specified in the relevant Material Specification shall make reference to the test method applied. If other test methods are used, correlation tests shall be performed.

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

5. QUALIFICATION:

5.1 Introduction:

Before approving a prepreg and film adhesive combination for repair it shall have successfully completed three stages:

a. Screening according to the screening program specified in AMS 3970/2 to verify the suitability of the prepreg system for qualification.
b. Qualification of the prepreg system in accordance with AMS 3970/2.
c. Additionally, each OEM referencing the specification may require additional tests before the prepreg and film adhesive system 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 PRI and the 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 PRI may be appointed. The screening and qualification program may be witnessed by PRI and/or the airworthiness authority representatives. The manufacturer shall keep on file and at the disposition of PRI all records (test graphs, process parameters, etc.) corresponding to the qualification for at least 5 years.

5.2.2 Screening of the Prepreg System: The screening test program may be 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 the PRI 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 3970/2. Material requirements are defined in the MS. The process parameters agreed between the prepreg manufacturer and the PRI shall be used, see 4.2.6.7.

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

5.2.3 Qualification of Material: The qualification is directed to raw material sources, the equipment and the processes which have been identified in the PCD. The qualification is also directed to the prepreg system, i.e., the composite. The tests required are defined in AMS 3970/2. Material requirements are defined in the MS.

5.2.3.1 Cross-Check: If required by PRI, a sample from one batch of the material shall be provided to PRI 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 prepreg system with other materials (e.g.; film adhesive, 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 the qualification batches.

PRI 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 PRI and the qualified prepreg system shall be added to the QPL. In addition to the performance of the prepreg system the IPS shall provide the qualified repair process parameters, cross reference 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 PRI 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, prepreg and film adhesive are specified in AMS 3970/2.

In the material qualification the following are applicable:

The first qualification batch may be the same as the one which was used for screening tests so the results of the screening can be incorporated into the qualification results.

The process parameters agreed between the manufacturer and the PRI shall be used, see 4.2.6.7.

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 products from the same batch or batches agreed with the PRI. The quantity of the test specimens shall be doubled. Material failing on retest shall be rejected and shall not be retested again without written approval by PRI.

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 6.3.
d. Aging and/or conditioning data prior to the test in accordance with 6.2.
e. Date of test, facility, equipment and identification of individuals performing 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 PRI 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	Prepreg	Film Adhesive	Side Qualification Program[1]
Replica of a qualified source	Qualified	Qualified	Qualified	Full qualification program except prepreg resin tests and film adhesive tests
New source	Qualified	Qualified	Qualified	Full qualification program except prepreg resin tests and film adhesive tests
Qualified	New weaver	Qualified	Qualified	Selected composite tests
Qualified	Qualified Weaver, New loom	Qualified	Qualified	Selected composite tests
Qualified	New fabric style	Qualified	Qualified	Full qualification program except prepreg resin tests and film adhesive tests
Qualified	Qualified	Replica of a qualified source	Qualified	All resin tests and selected composite tests
Qualified	Qualified	Qualified	Replica of a qualified source	Film adhesive tests and selected composite tests
Qualified	Qualified	New source	Qualified	Full qualification program except film adhesive tests
Qualified	Qualified	Qualified	New source	Film adhesive tests and all composite tests which include film adhesive

[1] The qualification program is defined in AMS 3970/2

5.5 Material Safety Data Sheet:

The material manufacturer shall provide to the PRI all the information about the material in accordance with health and safety requirements (See 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 OEMs in PRI and/or the purchaser.

5.6 Evaluation of Test Data:

Material qualification test data shall be evaluated by PRI:

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 3970/2.

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 3970/2.

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 5.3.1 and 6.1.8.
b. Traveler specimens; see 6.2.2.

6.1.3 Panel Manufacturing: Panel manufacturing shall be in accordance with the following:

a. Process the panels in accordance with AMS 3970/2 and the method specified in 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 6.6.1. The screening test results shall be used to establish the C-scan acceptance criteria.
d. Use approved panels for qualification testing in accordance with AMS 3970/1 and AMS 3970/2.

6.1.4 Tabs: The specimen should fail in the gauge length and in the specified failure mode. 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 properties are not influenced. Use a paste adhesive that cures at room temperature, reference Appendix A. The adhesive shall be approved by PRI.

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 in the composite material 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 traveler 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 Wet Conditioning Procedures: Laminates shall be wet conditioned by humidity aging in accordance with EN 2823 except for aging conditions and period which are specified in Table 3 and AMS 3970/2.

For sandwich panels age the panels before cutting into specimens. Seal the edges of the sandwich panels and the traveler specimens with metal foil tape to prevent moisture diffusion via the honeycomb core. Perform the humidity aging in accordance with EN 2823 except for the aging conditions and period which are specified in Table 4 and AMS 3970/2.

6.2.2 Traveler Specimens: Three traveler 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

6.2.2.1 Traveler 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. Traveler specimen edges shall be sealed, refer to 6.2.1.

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:

TABLE 2

Water	Specification not applicable	Distilled Water
Fuel	EN 2379, Test Fuel 1	JET A1, NATO code F-34, Kerosene-Low freeze point
Solvent	EN 2379, Methyl Ethyl Ketone (MEK)	Laboratory Grade
Hydraulic Fluid	EN 2379, Tri-N-butyl phosphate ester	Laboratory Grade
Hydraulic Fluid/Water Mixture	Tri-N-butyl phosphate ester / Distilled Water Mixture	Mixture: 50:50% by volume Mixture ready for use after 14 days storage at ambient conditions

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 3970/2.

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 traveler specimens with a paper towel or lint free cloth; determine the weight gain immediately after removal from immersion.

TABLE 3 - 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[4]	Specimen Test Condition[1]: Wet (Humidity Aged)
Panel, Subpanel and Specimen Manufacturing	Record 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]			-
Aging or exposure	-	Immersion in solvent at room temperature	Immersion in fuel at room temperature	Immersion in hydraulic fluid (or mixture with water) at room temperature	Aging in humidity chamber at elevated temperature
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 (or mixture with water as applicable), max time 8 hours	23 °C ± 5 wrapped in a wet towel, 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]Fluids are specified in 6.2.3.
[2]Exceeding the time limit requires measurement of specimen moisture content; refer to 6.1.8.
[3]Exceeding the moisture limit requires drying of the specimens; refer to 6.1.8.
[4]Hydraulic fluid or hydraulic fluid mixed with distilled water; refer to 6.2.3.

TABLE 4 - 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 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	Record 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%).	
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 6.2.1. Aging conditions are specified in AMS 3970/2.
[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.

6.3 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 at least include the following:

6.3.1 Panel Manufacturing: Report the complete identification of the materials to be tested, including material manufacturer identification, material characteristics, batch number, date of receipt, material receiving inspection and/or batch release report.

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

a. Panel manufacturing date
b. Individuals performing the manufacturing
c. Shop temperature and humidity
d. Conditioning of the materials
e. Time table for preparation, laminating, bagging and curing
f. Curing parameters, including the diagrams and the equipment used
g. Cutting procedure/drying
h. C-scan results, settings and equipment used
i. Measured thickness
j. Description of the used ancillary materials and the precise location of the thermocouple

6.3.2 Specimen Manufacturing: At least the following should be reported:

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 traveler specimens and the weight gain after immersion

6.3.4 Humidity Aging: Report in accordance with EN 2823:

a. Diagram about weight gain versus aging time
b. Condition and history of specimen before aging
c. Aging equipment and placement of panels in the equipment
d. Equipment control diagram about aging conditions and 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 PRI. 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 of 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 the test, 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 + 1/-0 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 traveler specimen. Determine from the mechanical testing performed on each laminate thickness the longest time from closing the temperature chamber to specimen failure. Put the traveler 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 +1/-0 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 3970/1 and AMS 3970/2 including any changes or additions defined in AMS 3970/1.

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 3970/1 are mandatory. It is not permissible to mix requirements of the alternate test methods.
b. Changes and additions specified in AMS 3970/1 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 Units 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 (nontool side).

Vernier caliper 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 the PRI 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. The number of specimens to be tested per test condition is defined in AMS 3970/2.
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. Fiber volume measurements are only required when specifically requested for a specific test method in AMS 3970/1.
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 / Warp: Reference specifications: EN2561-C or ASTM D 3039/ASTM D 3039M.

6.5.2.1 Specific Additions and Changes:

a. Laminate lay up: See AMS 3970/2
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: EN2561-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 3970/2
k. Specified failure modes: Tension failure within the gauge length lateral or angle direction

6.5.3 Compressive Weft / Warp: Reference specification: EN2850-B.

6.5.3.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 3970/2
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, than 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/ASTM D 3518M.

6.5.4.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 3970/2
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 microstrain
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 3970/2
For adhesive specimen prepare laminate in full depth from necessary number of adhesive layers
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 3970/2
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/ASTM D 5766M.

6.5.7.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 3970/2
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 3970/2
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 3970/2
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 3970/2

6.5.11 Compression After Impact: Reference specification: EN 6038.

6.5.11.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 3970/2
b. Impactor roughness: Ra <0.8 µm
c. Number of impact energy levels to be tested in compression: 3 levels determined in accordance with 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 that 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.

6.5.11.2 (Continued):

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 indention 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, PRI 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 3970/2. 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 6.7.6 using Aramid paper based phenolic honeycomb referenced in AMS 3970/2
d. Facing block material: Al 2024-T351, 25 mm thick
e. Bonding of aluminum facing blocks: See 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. Curing of blocks on specimens which have been aged shall be done in a humidity chamber at 70 °C ± 2 and 85% RH ± 3. The selected adhesive shall be approved by PRI, see Appendix A 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 3970/2
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 6.7.6

6.5.13.1 (Continued):

g. Specimen width: 75.0 mm ± 0.1
h. Specimen length: 610 mm ± 1
i. Specimen position for testing: Repair skin in compression
j. Specified failure mode: Compression failure of the repair skin or debonding of the honeycomb core and the repair skin in the area inside 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 3970/2
b. Specimen manufacturing: See 6.7.7
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 3970/2
b. Specimen manufacturing: See 6.7.7
c. Joint length: 75 mm

6.5.16 Tensile Single Lap Shear: Reference specifications: EN 2243-1 or ASTM D 1002.

6.5.16.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 3970/2
b. Use EN 2243 Type 1

6.5.17 Thick Adherent Shear: Reference specification: EN 2243-6.

6.5.17.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 3970/2

6.5.18 Moisture Uptake: Reference specification: EN 3615B 85.

6.5.18.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 3970/2
b. Exposure temperature: 70 °C ± 2

6.5.19 Fracture Toughness Energy - G1c: Reference specification: EN 6033.

6.5.19.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 3970/2

6.5.20 Fracture Toughness Energy - G2c: Reference specification: EN 6034.

6.5.20.1 Specific Additions and Changes:

a. Laminate lay-up: See AMS 3970/2

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 3970/2.

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 the PRI.

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

a. Detect delamination
b. Detect core skin disbonds
c. Determine the homogeneity of the panel with respect to porosity

Acceptance and rejection criteria will be determined by the PRI.