

REPORT

Composite Test Methods Standardisation: Trends and Issues

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ABSTRACT

Currently, there are many issues and pressures on the standardisation system. Many of the factors are long standing, others are the result of the evolution of the composite industry and in particular its international dimensions. Since 1989 there has been active appreciation and support for harmonisation of existing test standards. Existing standards are being rationalised and harmonised but quicker results could be obtained by developing a policy on the creation of new standards. The demand from the EU single market for EN standards is assisting this process.

The different trade, research and defence groups bodies are extremely useful for developing test methods during the "evolution" phase, especially if providing experimental validation evidence, in support of the international standardisation bodies. The important point is that at a stage, that is not easily defined, alternative proposals should be tabled in an attempt to obtain a common viewpoint. This is the role VAMAS attempts to fill by undertaking projects in areas where new standards are expected to be needed in the next few years.

In this report the current international status of EN-ISO composite test methods for general engineering and the EN Aerospace series is reviewed. The report proposes that ESA could adopt the harmonised EN-ISO standards as the UK and European preferences were taken into account but that AECMA companies could provide technical expertise and draft documents in support of these triple numbered standards and other ISO work items.

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Approved on behalf of Managing Director, NPL, by Dr C Lea,
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1. INTRODUCTION

The range of industries and applications where fibre-reinforced plastic/composite materials can be found continues to grow; and it is not limited to the more glamorous aerospace industry. The maturity of the industry, the existence of the European Single Market and the globalisation of trade and companies are all factors leading towards a rationalisation of test methods and qualification procedures. All factors are subsidiary to the cost implications of a) developing and publishing multiple versions of standards and b) using multiple standards in qualification, research and design.

These needs are encouraging greater levels of international cooperation on standardisation activities, principally through the International Standards Organisation (ISO), and on collaborative pre-standards research. It was found in [1] that there was good agreement on the basic philosophy between different test methods and that differences were generally not technically justifiable. Significant progress, as discussed below, has been made recently on harmonised standards. These will be available in European countries as triple numbered standards (eg BS EN ISO/.....) for engineering use of composites in all industries.

The production of these standards was catalysed by the increased standards activity in Europe. In the EU a requirement was identified for European standards to be developed, by Comité Européen de Normalisation (CEN), in support of the European Single Market. Common standards are necessary, for both free trade and product liability aspects, if the market is to operate as planned. EN standards developed by CEN gain their importance because it is mandatory both to publish them in countries within the European Union, and EFTA countries, and to withdraw any national or ISO dual numbered standard of the same scope. Mandatory European Directives published by the Commission, such as that on "Construction", are underpinned by these CEN standards. Although compliance with these European Directives can be shown by other routes, the need to prove equivalence using technical experts etc. makes alternative routes un-economic. In addition to a general engineering series, equivalent to ISO standards, a separate EN Aerospace series produced by ACEMA (European Association of Aerospace Industries) exists which, as discussed later, are not automatically replaced due to their restricted Aerospace scope.

This report considers these developments against the specific needs of the European space industry as represented by the European Space Agency and its relationship to European (EN) Aerospace standards generated by AECMA. These standards are principally driven by the aircraft industry rather than the space industry. Currently, the ESA viewpoint on testing is documented in Chapter 7 of the ESA Structural Materials Handbook, PSS-03-203. The draft revision (dated 5 February 1996) has more information than previously on ISO standards.

Section 2 discusses the different standardisation forums involved because their structure, history and future survival is at least an important factor as the technical issues involved on standardisation activities. In Section 3, the harmonisation forums and initiatives are discussed, while in Section 4 some examples illustrating different levels of approaches and complexities are given. The current status of other harmonised test methods are discussed in Section 5. Further work on new topics are reviewed in Section 6. The current AECMA-ISO harmonisation initiative is reported in Section 7, followed by concluding comments in Section 8. Appendix A lists recommended test methods based on ISO standards. The current work programmes of ISO TC61/SC13 and CEN TC249/SC2 are given in appendix B and C.

2. STANDARDISATION FORUMS

A survey in 1992 [2] identified 9 ISO and 24 CEN Technical Committees (TCs) potentially related to composites. Some of these TCs were established composites areas (eg TC155 Plastics Piping and Ducting Systems, TC210 GRP Tanks), others were areas which required

monitoring to ensure that the specifications being developed for different products or applications did not unnecessarily prevent composites meeting the requirements.

Two aspects of particular note for space applications, compared to aircraft application related to the major need to save weight in space vehicles, are the use of the higher stiffness carbon fibres and the use of thin skins in sandwich structures. In this section the material specification and test methods aspects only are considered.

2.1 ISO - TEST METHOD AND SPECIFICATION STANDARDS (ISO TC61/SC13)

The main forums for standardisation were for many years either through national bodies (eg AFNOR, ASTM, BSI, DIN) or via their role in support of ISO standards. As ISO standards had no legal standing, countries were not precluded from producing national standard of the same scope better suited to local requirements or local historical practice. Although, in practice, many ISO standards have been dual numbered as national standards (eg BSI 2783 Method 335A is the same as ISO 178). For example, although a member of ISO and holding the secretariat for all plastics standards under TC61, the USA composites community has concentrated on ASTM standards produced by the D-30 committee. This committee has had little involvement in ISO composite standards until recently encouraged by the author in spite of its background of relevant test methods. This contrasts with the involvement by the ASTM D20 (Plastic) committee in ISO Plastics standards.

At the materials testing and specification level, the work within ISO is undertaken in TC61 (Plastics), mainly within sub-committee (SC) 13 - Composites and Reinforcement Fibres. In addition to this, many other sub-committees, such as SC2 dealing with mechanical test methods, SC4 for fire tests and SC12 - Thermosets, develop relevant test methods covering both unreinforced and reinforced plastics. The secretariat of TC61 is held by the American National Standards Institute (ANSI) on behalf of USA. The sub-committees forming SC13 are shown in Table 1. WG12 is working on combining glass- and carbon-fibre test methods when technically acceptable (eg linear density). European countries provide all but one of the ISO convenors.

Table 1 Structure of ISO TC61/SC13

NUMBER	TITLE	CONVENOR/COUNTRY
SC13	Composites and reinforcement fibres	Guillermin/France
SC13/WG11	General standards	Downey/UK
SC13/WG12	Reinforcement fibres	Charlier/Belgium
SC13/WG13	Glass-fibre standards	Toustou/France
SC13/WG14	Carbon-fibre standards	Matsui/Japan
SC13/WG15	Pre-pregs and moulding compounds	Garcia-Folques/Spain
SC13/WG16	Composites mechanical test methods	Krawczak/France

There are currently in excess of 65 ISO standards related to composites at the material level. The majority of these are published standards, mainly requiring review and maintenance, with about 10-20% as new work items.

2.2 EUROPEAN STANDARDISATION

In Europe there is both a general series, linked to ISO standards, and a separate aerospace series of test methods; although for high performance preimpregnates similar data are required for both aerospace and non-aerospace applications.

2.2.1 CEN TC249/SC2 - General Standards

In order to meet the basic material specification and test method standards needed in Europe, CEN/TC249 for plastics was established in 1991 with five sub-committees. The general engineering use of reinforced plastics/polymer matrix composites has been covered by five working groups within CEN TC249/SC2 (see Table 2). Working Group 1 (WG1) is responsible for both the product specification and the supporting test methods for all small/textile diameter fibres (eg carbon, glass and aramid). WGs 2-4 are responsible for specification standards for each class of material and for test methods only applicable to a single material (eg flow of DMC). WG2 is currently maintaining a watching brief to determine if documents produced by ACEMA can be modified so as to be acceptable for general use (eg including incorrect use of AECMA-CERT from several clauses). However, see comment below on CEN-ISO interactions via Vienna agreement.

Test methods applicable across the range of materials in WGs 2-4 are covered by WG 5, convened by the author, to ensure compatibility of test methods for all composites. It has been agreed that all new standards must be validated and that the scope should be as wide as technically acceptable, to cover existing and new materials. WG 5 has completed most of its initial work and most new test method standards will be lead by ISO. A sixth working group, WG6, has been recently added to prepare standards for "pultruded profiles".

Table 2. Structure of CEN TC249/SC2

TC249/SC2 - COMPOSITES, REINFORCEMENTS AND PREPREGS (Convenor/country = Gulliermin/France)			
Standing Advisory Group (Henrat/France)	WG1 Reinforcements (Charlier/Belgium)		
	WG2 Thermosets - aligned (In abeyance/Italy)	WG3 Thermosets - random (Kannebly/ Germany)	WG4 Thermoplastics - All except injection mouldings (Downey/UK)
	WG5 Structural and Common Test Methods (Sims/UK)		
	WG6 Pultruded Profiles (Sims/UK)		

As CEN is principally concerned with material specification standards, it looks first towards ISO for test methods and then to other existing European and national standards. ISO standards which are considered satisfactory are being adopted as CEN standards by a Unique Approval Procedure (UAP) ballot, which requires a YES or NO vote without comment. This procedure is used extensively by CEN TC249/SC1, where some 150 existing ISO standards for plastics are to be re-balloted as ENs once the German versions are available. Several of these methods are applicable to polymer matrix composites as well as other plastics. Few of the existing standards, produced by ISO TC61/SC13 on laminate test methods were suitable for UAP vote as they were restricted to glass-fibre based systems when documents with wider scopes were required. Some designation or specification standards for textile glass-fibres and their secondary products (eg yarns) are being adopted by this route. Several test methods (EN 59-63) were published in 1979, with minor alterations from the equivalent

ISO standard, to support a directive on the "use of GRP for carriage of hazards materials". These EN standards will be replaced by the new EN-ISOs when published.

2.2.2 European Aerospace Standards (AECMA)

CEN has delegated responsibility to develop EN aerospace standards to AECMA. However, the AECMA balloting structure has not always allowed non-aerospace interests, including national committees, adequate opportunity to comment on these standards so that cross reference to ISO standards has not always been satisfactory. In addition, depending on the country, the national shadow committees may not be the same committee for both general and engineering standards (eg UK has two committees, Germany only one), further complicating good liaison. The work on "reinforced plastics" is conducted in C7/WG5 convened by M. Bugarde (France), who attends CEN TC249/SC2 for liaison purposes. AECMA cancelled several planned carbon-fibre standards and adopted newly published ISO standards but is still progressing a carbon-fibre designation standard alongside a similar ISO standard, with both documents referencing the same ISO test methods. It is not good publicity for standardisation if a specific fibre can be designated by two incompatible codes.

Most of the early standards developed by AECMA were restricted to a single material class (eg glass-fibre or carbon-fibre systems) and resulted in multiple incompatible methods. More recently prepared standards do have wider (material non-specific) scopes similar to ISO. Although CEN is more concerned with specifications than test methods, as noted above, AECMA has been developing a full separate sets of test methods for each fibre type. While, these were often similar to other standards some significant differences did and still do exist (see Sections 5-7).

Recently, following encouragement from CEN/ISO contacts, C7 now has a policy that is committed to reviewing equivalent ISO standards when existing AECMA standards were at the 5 year revision stage. Five standards are currently being reviewed by the C7/WG5 ISO harmonisation committee (see Section 7). ISO standards will also be considered when initiating new work. Equally, the project leader for the harmonisation activities described below used several EN aerospace series standards as source documents.

Some Airbus Industries methods (ie AITMs) are able to be entered partway through the approval process, as the 6000 series, due to an agreement between AECMA and Airbus. There is concern that national aerospace and general committees in Europe have not had the opportunity to comment on or ballot any 6000 Series documents to date. In some cases, as detailed later, they duplicate ISO work. As noted earlier these AECMA 6000 series standards have not been involved in the harmonisation initiative, although, some Airbus Industries methods are preferred, by the author for future standard projects, to other available methods (eg pin-bearing test), while other AITM-based methods would not be supported (eg technical differences compared with majority view or poor drafts).

2.3 USA STANDARDISATION and ASTM

The major source of composite standards in the USA is from ASTM (American Society for Testing and Materials) but many other organisations also contribute such as SAE and Department of Defence (DoD). There is a similar need and continuing initiatives for harmonisation within the USA, as for the international scene. The DoD has a published policy of using more "commercial" standards (ie ASTM standards) in preference to developing specialised version at great cost for their own limited use.

ASTM D30 committee has a fairly complete suite of standards with some validation evidence. A positive interaction has been initiated with ASTM setting up an international liaison committee following the first approaches from ISO and CEN contacts. As noted elsewhere there has been good cooperation on the harmonised standards (see Sections 4-6). The actual

ASTM documents are generally longer, give more general guidance, include suppliers details (NB this cannot be included in ISO standards) and the text is often less rigorous compared to the minimal legal requirements described and allowed by the drafting rules in CEN and ISO standards. The two versions are, usefully, complimentary when harmonised on the technical aspects.

3. HARMONISATION FORUMS

This section considers the different forums where harmonisation can occur.

3.1 ISO-CEN COLLABORATION - VIENNA AGREEMENT

The Vienna Agreement on sharing of the work load between ISO and CEN allows either organisation to lead work items, with agreed responsibilities for consultation and timescales. A parallel voting procedure is used, so that the approved document becomes both a CEN and an ISO standard; or one or other if not agreed by both ISO and CEN. Depending on the lead organisation, different responsibilities apply. For CEN led work care must be taken to consult fully with non-CEN countries. For ISO led items, then ISO must work quickly to match the fast development of standards required in Europe, however, faster development of standards is an increasing requirement in ISO itself. Liaison is easily accomplished as the ISO and CEN President and secretariat (AFNOR) are the same and many of the leading ISO WG members and convenors are also CEN convenors.

3.2 INTERNATIONAL PRE-STANDARDISATION RESEARCH - VAMAS

To avoid the need to undertake protracted harmonisation on existing standards is one aim of the VAMAS (Versailles Project on Advanced Materials and Standards) initiative through collaborative international pre-normalisation research. The programme is chaired alternately by the UK (NPL) and the USA (NIST). The overall objective is to promote trade in high technology products through international collaboration in pre-standards research. This generates the technical basis from which common accepted standards and specifications for advanced materials can be developed. The initiative is supported by Canada, France, Germany, Italy, Japan, UK, USA and the EEC. Other countries can apply to participate in individual projects.

It is the intention of this initiative that the technical work conducted should result in a recommended procedure that would be supported by all the VAMAS members countries to produce an agreed international standard test method and that the VAMAS work will provide the necessary validation evidence. Examples of current activities are given below.

(a) Fatigue (ISO 13,003).

Data obtained in a VAMAS fatigue round-robin [3] have been used to modify a French proposal dealing with several modes of flexural fatigue testing. It was agreed that Part 1 alone would be considered as a general procedure for fatigue testing and would reference equivalent static test methods, such as the new harmonised ISO standards. The data and experience available from previous NPL fatigue programmes and the VAMAS round-robin (RR) have been used to modify the original proposal.

(b) Fracture Toughness (ISO 15,024)

In order to make progress on the Mode 1 Fracture Toughness, for which there was agreement, at the 1995 ISO TC61/SC13, meeting it was necessary to overcome the Japanese objection, which was based on progressing both Mode I and Mode II fracture toughness methods at the same time. The author, as chairman of VAMAS TWA5, offered to run an

intercomparison of the 3 competing Mode II methods from Japan, USA and Europe. This work is in progress using materials supplied by the Japanese and led by an ESIS (European Structural Integrity Society, previously European Group on Fracture) member in France, Dr P Davies. This involvement builds on prior VAMAS work on this topic alongside ASTM, JIS and ESIS RRs.

(c) Compression-after-impact

This topic arose from a review of several versions of "compression-after-impact (CAI)" tests developed in the aircraft industry to study the effect on residual compression strength of "barely visible impact damage" (BVID). Although the Boeing version is most popular and the basis of the Airbus method there is a need to refine it and to consider (cheaper) alternatives such as a miniature version. It was agreed that the programme would look fundamentally at the general design requirements for measuring material resistance related to damage tolerance in structures before, if appropriate, working on standardisation of the currently developed CAI test. The Japanese are leading this task, as a continuation of their strong support for VAMAS.

(d) Interfaces

A new topic area on measurement of "interface" characteristics is being developed by NIST. A full VAMAS work programme proposal is expected shortly. This work area anticipates future needs as in spite of the importance of interfaces to the behaviour and performance of composite materials, there are no established test methods or standards.

3.3 OTHER GROUPINGS

Other groups also contribute to developing common viewpoints, for example

(a) Research Grouping

ESIS has been active mainly on fracture toughness, with many round-robins aimed at validation of the draft test methods produced. It submitted the drafts for both Mode I fracture toughness tests for polymers and for delamination in composites, provided one of the Mode II methods and are submitting several other proposals for assessing toughness of polymers.

(b) Trade Groupings

Several collaborative commercial groups exist in Europe, such as European Fighter Aircraft [EFA], Eurocopter and Airbus. In these cases due to the absence of agreed international standards, sets of methods have been established for each "project", with varying degrees of opportunities to influence international standards. It is understood that EFA tests not covered by Airbus methods have been submitted to AECMA for future standardisation.

Supplier trade federations that had relevant activities were SACMA in the USA, ETAC in Europe and the BPF in the UK. SACMA published a set of well produced recommendations with several based on ASTM standards with useful simplification (eg tensile test). The biggest remaining need was obtaining their adoption by other bodies such as the USA aerospace manufacturers. ETAC considered similar activities and initially approached SACMA. Currently, ETAC are responding to Airbus regarding adopting Airbus standards.

The BPF Composites Group adopted the CRAG [4] recommended test methods (see below) and sponsored them as BSI standards. Standards could not be immediately drafted as standards as in agreement with all standards drafting rules, BSI demanded evidence of experimental validation to obtain precision data. However, delays in BSI and events in CEN

and ISO overtook this initiative but the CRAG methods did form an input in the subsequent harmonisation work. Similarly, the Japanese Carbon Fibre Manufacturers are active in supporting JIS standards. Japan will apply ISO standards when available and withdraw JIS standards.

(c) Defence Groupings

As well as defence standards themselves, a task force of the UK Composites Research Advisory Group (CRAG) started work in 1982 on recommended methods. Membership included Ministry of Defence establishments and Society of British Aerospace Companies - both suppliers and manufacturers. The resultant recommendations have been extensively quoted as they formed the best series of updated test methods applicable to all fibre types, as unidirectional, multidirectional or fine fabric reinforced composites treated in a consistent manner. Recent harmonised drafts (see Sections 4-5) have drawn on these recommendations, amongst others.

4. HARMONISATION EXAMPLES

In this section, some examples of harmonisation approaches are described, with some degree of optimisation. It should be noted that a variety of approaches are used but the important factor is developing a single test method. It is likely that following this harmonisation, a further optimisation or new methods will be proposed by comparison with the "reference" method.

4.1 CEN INITIATED - MASS PER UNIT AREA (cf EN 2329 and 2557 [5-6])

The method of working prescribed for the CEN sub-committees (ie initial review of existing standards) has resulted in a unique opportunity to assess the suitability of existing standards for acceptance as CEN standards. It is an essential requirement that the generation of these under-pinning standards should be rapid in order to allow the single market to function effectively. In some cases an existing ISO can be revised quickly by CEN.

For example, ISO 10352 : 1991 on mass per unit area [7] covers within its scope both aerospace prepreps and general moulding materials. Two CEN (General series) WGs wished to adopt this standard, but the specimen size given was too large for aerospace type prepreps. CEN WG 5 revised the standard, prior to the normal five year revision, in 1995 by including a second smaller size specimen and several other clauses from the EN aerospace standard for carbon-fibre systems [6].

CEN TC249/SC2 then requested ISO to revise the ISO standard on the basis of the new draft. The revised standard has now been published. The involvement of CEN has allowed an early and rapid revision of an existing ISO standard. It should allow two slightly different EN Aerospace documents for carbon-fibre and glass-fibre systems to be withdrawn [5-6].

4.2 ISO INITIATED - TENSILE TEST (cf EN 2561, 2597 and 2747 [8-10])

The re-draft of "ISO 527 - Tensile test for plastics" has resulted in two complementary parts for composites; Part 4 [11], based on ISO 3268 [12], covers "isotropic and orthotropic" materials and Part 5 covers "unidirectional" materials [13]. These parts were drafted by the author working in co-operation with colleagues from other countries. The main technical requirement was to obtain a harmonised version for the totally new Part 5. Inputs were included mainly from ISO 527-1 [14], ASTM D3039 [15], JIS 7073 [16], CRAG 300 [4], EN 61 [17] and EN aerospace methods). ISO DIS 527-5 [13] has been parallel voted as a CEN standard and should, with Part 4, replace EN61 [14] and possibly two Aerospace EN

In all cases, the approach and conditions represented in ISO 527-5 were introduced into the new documents using a consistent clause structure and content whenever applicable. For example, clauses on tab material, specimen preparation, etc. are repeated from previous documents. This should make it easier to prepare the standard and for users to understand and reduce costs in specimen preparation and testing by the consistency enforced.

Table 3 Remaining differences for tensile test methods

PARAMETER	OPTIONS	STANDARDS
Modulus measurement	Strain based (EN ISO 0.05%-0.25% or ASTM 0.1%-0.3%)	ISO, EN General , ASTM, JIS, CRAG.
	Load based (cf allowable strain design limits used).	EN Aerospace.
Material scope	All fibres covered by one standard	ISO, EN General, ASTM, JIS, CRAG.
	Fibre specific, several versions needed	EN Aerospace.
Application area	All	ISO, EN General, ASTM, JIS, CRAG.
	Aerospace only	EN Aerospace.
Tab angle	90° degrees	ISO, EN General, JIS, CRAG, EN Aerospace.
	Tapered (7°-90 degrees)	ASTM.

4.3 CACRC - AN UNFORTUNATE COMPROMISE

Recently, an important and major international initiative on repair involving companies from airline operators through to material suppliers has resulted in a clear illustration of the difficulties arising from an absence of international standardisation. The Commercial Aircraft Composites Repair Committee (CACRC) is organised by SAE, IATA and FAA into several task forces. Pivotal work involves the establishment of test method for the qualification of pre-preg and wet lay-up repair material. Initially, the EN Aerospace standards proposed were vetoed by the FAA following review by ASTM experts, causing extensive difficulties and loss of time due to the absence of an internationally agreed method for each material property.

Table 4. Typical additions and changes by CACRC to an EN Aerospace standard.

Property: Tensile weft (test of a fabric reinforced laminate)

Standards: ASTM D3039 and EN 2561

Specific additions and changes:

PARAMETER	CACRC PROCEDURE	ASTM D3039 PROCEDURE	EN 2561 PROCEDURE	ISO 527-4 and 5 PROCEDURE
Modulus measurement	Strain (0.1% to 0.3%)	Strain (0.1% to 0.3%)	Load (0.2 to 0.5 of peak)	Strain (0.05% to 0.25%)
Specimen width	25 mm	25 mm	15 or 10 mm	25 mm
Material applicable	Fabric	Fabric	Unidirectional	Fabric, mat , multidir.
Gauge length	≥ 125 mm	≥ 125 mm	90-150 mm	150 mm

Currently, a poor compromise has been adopted in this programme. For most test methods, an ASTM and an EN Aerospace standard are recommended as equivalent but several exceptions are made, particularly to the ENs, to obtain equivalence (eg use of strain levels for modulus rather than load-based as in the EN Aerospace standard). These compromises are similar to those made in the ISO harmonisation and it is hoped that now CACRC is aware of the recent progress by ISO, that the ISO standards will be adopted in the next review. Because of the wide international range of companies and bodies involved in this work the results could have wide implications. An example of the compromises involved is given below. It is felt that these significant changes, which have been arbitrarily agreed (ie not passed through any balloting stage or international committee) and since supported by CACRC members, undermine the published EN aerospace standards.

5 CEN LEAD PARALLEL EN-ISO STANDARDS AT FINAL BALLOTS

In this section each of the relevant laminate test methods are reviewed to assess the current trends and significance. In a concluding section recommendations are given for preferred test methods to be gradually adopted as and when appropriate.

5.1 COMPRESSION (cf EN 2850 [19])

Compression (EN ISO/DIS-2 14,126 [20]) - based on ISO 8515 [21] with input from EN 2850, ASTM D3410 [22], CRAG 400 [4] and SRM 1-88 (ie ASTM D695) [23] modified. A framework has been developed in order to rationalise the many test methods and even greater number of loading fixtures/jigs. The approach taken is to concentrate on the quality of the test by requiring the specimen to be strain gauged on both faces and for the test to be completed, or terminated, within a bending (buckling) strain of less than 10% of the axial strain.

Concentrating on the quality of the test allows for a range of jigs to be used, for the continuing development of jigs and ensures that established tests are used correctly. Both shear face loaded and end loaded jigs, as in ISO 8515, are allowed. The jig used must be quoted, either an established jig from those listed in the annex or any other that is used. It should be noted that the ASTM D-30 committee sent back their completed revision of ASTM D 3410, shortly before publication, in order to achieve greater harmonisation with the CEN/ISO standard (ie 10 mm widths and gauge lengths rather than 12.5mm (~0.5 inch)).

This standard is currently at DIS-2 ballot to allow a disposition, requested by the USA, that providing the first five specimens fail correctly within the 10% bending strain criteria, further specimens of the same batch, same operator, equipment etc, can be tested without, or with a single, strain gauges.

A second specimen size, 25 mm wide by 25 mm gauge length is now available for fabrics, mats and multidirectional lay-ups but uses a 4 mm or greater thickness based on ASTM D3410 guidelines to avoid premature failure by Euler buckling. There was no general support for including the machined specimen in prEN 2850. This specimen requires a separate special laminate lay-up, careful machining and polishing of the cut faces and radii. This is not a preferred situation for general engineering use when a finished test panel is supplied to obtain a set of properties. The results for this specimen are inconclusive, as some materials have shown improved results, while others have recorded lower strengths.

5.2 INTERLAMINAR SHEAR STRENGTH (cf EN 2377 and 2563 [24-25])

Interlaminar shear test (EN ISO/F-DIS 14,129 [26]) - based on ISO 4585 [27] with input from ASTM D2344 [28], CRAG 100 [4], EN 2377 and EN 2563. The only significant change is to use a 2mm thick standard specimen to accommodate the existing preferences when testing

prepregs. Other thicknesses are accommodated by the existing scaling rules. There is an increased emphasis on accepting only interlaminar shear failures as valid results.

5.3 IN-PLANE SHEAR (cf prEN 6031 [29])

In-plane shear by $\pm 45^\circ$ tensile test (EN ISO/F-DIS 14,130 [30]) - based on ASTM D3518 [31] with input from prEN 6031 and CRAG 101 [4]. It applies to all fibres and in common with the ASTM revision, the test will be terminated at 5% shear strain with a subsequent shortening of the normally excessive test duration for tougher matrix systems, which gives a very flat load-time response for materials with high shear failure strains. The 5% limit also minimises fibre rotation and heating effects. The peak load at or before 5% strain is taken as the shear strength.

It has been reported that the result is dependent on the number of layers, or shearing interfaces, in the specimen [28]. This may have technical and harmonisation implications for the Airbus Industries/prEN 6031 version [29], which is the only version of this test using 1 mm thick specimens (cf 2mm in all others). It is recommended that the number of shearing faces (eg interfaces) should be kept constant when ply thickness vary from the normal 0.125 mm plies.

5.4 FLEXURE (cf EN 2562 and 2746 [32-33])

Three and four point flexure (ISO/F-DIS 14,125 [34]) - based on ISO 178 [35] with input from ASTM D790 [36], JIS 7074 [37], EN 63 [38], CRAG 200 [4], EN Aerospace 2562 and 2746. The major changes are the addition of a 4-point loading configuration, and a larger test span-to-specimen thickness ratio test condition for unidirectional carbon-fibre based systems. Materials are divided into four classes related to their structure and ratio of Young's Modulus to through-thickness shear modulus. Care is required in determining the failure mode. In some cases failure of the compression face can be avoided by use, optional, of a 0.2 mm thick pad beneath the centre loading roller, following Japanese practice. However, flexure tests would not be recommended for the determination of design data.

The CEN-led standards described in this section, excluding compression, were awaiting circulation by CEN on a two-month final ballot but delayed by the German translation of the DIS level ballot corrections. Recently, these documents were circulated by ISO for parallel vote as this route does not require the German version to be available until six-months following a successful ballot. The compression will have short two-month technical ballot prior to the formal ballot.

6. RECENT AND NEW WORK ITEMS

6.1 FRACTURE TOUGHNESS (cf prEN 6033 and 6034 [39-40]).

Mode I based on ESIS document with USA project leader is currently being balloted. Several round-robins were conducted by ESIS, ASTM, VAMAS and JIS during the development of these methods. Mode II is being studied in a VAMAS lead project. The Airbus based method uses a shortened Mode I specimen for the Mode II test, in contrast to using one of the alternative Mode II specimens.

6.2 OPEN HOLE TENSION (cf prEN 6035 [41])

The use of a 6 mm diameter hole in a 36 mm wide plate as in ASTM D5766 [42] is acceptable to many in the UK and Europe. The "hole diameter diameter-to-plate width" ratio of 6/1 also allows an equivalent English size version of 0.25" on 1.5" plate, if required, which is included in [42] as an alternative specimen. The standard gauge length for tension test of 150 mm is

satisfactory as failure is focused at the hole site and the longer length proposed here is not required. NPL has prepared a draft of this method based on EN ISO 527-4 and ASTM D 5766, which has been approved for submission as a ISO new work item (NWI). ISO 527 4 [11] can be used for the control unnotched test using a 25mm width specimen in preference to the new dumbbell specimen in prEN 6035.

6.3 OPEN/FILLED HOLE COMPRESSION (cf EN 6036 [43])

The SACMA jig preferred by the CACRC committee uses a large amount of material due to the size of the specimen with the possibility of end-failures and either unknown degrees of constraint (Airbus jig) or unknown load carried by the jig itself. Boeing appear to have changed their specimen from the earlier version now being progressed by ASTM and SACMA [44]. The new specimen is closer to the Airbus standard, prEN 6036 with a 30 mm gauge length. EN ISO 14,126 [20] as a result of ballot comments includes a 25 mm wide specimen that can be used (25 mm gauge length) - it was based on ASTM D3410 recommendations to avoid Euler buckling of the specimen. NPL has used the test for a wide range of materials. An unsupported test, if stable, is preferred to those with using constraints, which do not apply easily repeated conditions and some of the applied test load can be covered by test. The 25 mm wide compression specimen in EN ISO 14,126 can be used for the control unnotched specimen.

6.4 PIN BEARING (cf EN 6037 [45])

The plain pin geometry used in prEN 6037 is probably on the basis of recent NPL research using a wide variety of composites, the preferred material/base level test as it avoids the difficulty of choice of torque, choice of failure criteria, degree of stress relaxation, washer size, coefficient of friction etc. The draft ASTM test method includes several different configurations. The harmonised version could use a plain pin as the base value and allow in an annex some of the alternatives. However, the same 6 mm on 36 mm sizes (or 0.25" on 1.5") should be used to reduce the cost of specimen preparation, etc.. NPL has drafted a method using the 6 mm on 36 mm size, common with the two open hole specimens, that is the subject of an ISO new work proposal by BSI.

6.5 COMPRESSION-AFTER-IMPACT (CAI) (cf EN 6038 [46])

The CIA test is expensive to undertake because it uses a large specimen. It is also rather arbitrary in nature. It would be useful to preform the first phase using ISO 6003-2 [47] (instrumented plate impact - 100 mm diameter support now allowed) so that a standard procedure can be used and extra data quantifying the impact (eg energy absorbed, peak load and displacement). Airbus version of this original Boeing derived test require extra material to obtain confirmation of critical energy level currently based on a dent (cf delaminated area by C-scan), although the dent size continues to vary. Dent depth was found in major USA programme to be unreliable.

Researchers in Japan and UK have proposed a smaller specimen, which effects particularly material cost and test machine capacity in compression phase of test. VAMAS has started a work item on this topic following a meeting at the ICCM-10 conference in Whistler, Canada which included a supportive presentation by the ASTM sub-committee chairman, from Boeing, for structural tests. The current CAI test has been shown to be less satisfactory in circumstances different from the initial problem (eg thicker material).

6.6 GELL TIME (cf prEN 6043 [48])

ISO is currently using ASTM D3532 [49] and JIS K7071 [50] for a Japanese prepared draft (ISO/CD ??[51]). This is a basic test using draw of a resin with a glass rod. AECMA should submit the draft of their multiple method standard to the Japanese project leader as

incorporation of the more scientific tests from EN 6043 would improve the ISO standard. Viscosity is also included in EN 6043, which should be compared with the dynamic rotary oscillator test method in ISO/CD 6721 Part 10 [52].

6.7 GLASS TRANSITION TEMPERATURE (cf prEN 6032 [53])

The AECMA draft should be compared with the basic test method being developed in ISO TC61/SC5 (Thermal properties) to determine if it meets their requirements. SC13 has decided not to progress its similar work item; but await the outcome of the more generic work in SC5 and produce an annex covering the particular use of DSC for cure monitoring.

6.8 CURE CHARACTERISTICS BY DSC (Differential Scanning Calorimetry) (cf prEN 6041 [54])

As above in Section 6.6

6.9 CARBON-FIBRE VOLUME FRACTION (cf EN 2559 [55])

Input into ISO/DIS 11667 [56] could ensure this standard is acceptable to AECMA.

6.10 CARBON FIBRE DESIGNATION (cf prEN 2962 [57])

This subject has been difficult to resolve due to the inclusion of two alternative methods of measuring modulus (eg strain and load based as described previously) as both proponents have been un-prepared to compromise their position. It has now been agreed that the strain-based value should be the reference. As both alternatives will reference the ISO test methods, use of the ISO designation [58] will ensure future compatibility (see Section 2.2.1).

6.11 IN-PLANE SHEAR MODULUS BY PLATE TWIST

Draft and validation data supplied by UK. Method is cheap and simple using a flexure test jig. No special lay-up required but material should look "homogeneous" through the thickness (ie. there should be several 0°/90° layers not [0°/90°/0°]). This test method is on a fast approval acceptance as ISO/CD 15,310 [59]. No AECMA equivalent exists.

7. AECMA-ISO HARMONISATION APPROACH

The AECMA C7 committee has suggested a three-pronged approach for test method standardisation related to ISO standards as both the C7 and C7/WG5 convenor believe test methods should be prepared by ISO, as follows:

- a) Adopt ISO standards where these are available and appropriate (this happened to the carbon fibre test methods in advance of this policy statement),
- b) Where ISO's exist but a problem is foreseen, AECMA will approach ISO to resolve concerns. Project requirements may require a prEN (or company/project method) as an interim solution,
- c) In cases where an AECMA document was the source of an ISO document, then AECMA will be maintained until five year review, when the ISO will be adopted and the EN Aerospace cancelled; and
- d) AECMA-CERT will be removed from all documents following explanation of CEN rules, except in prEN3042.

Case (c) can be applied more generally and at any time. AECMA C7/WG5 has initiated an ISO harmonisation working group, which is comparing five AECMA standards on five-year revision. Excluding the minor differences to be checked (eg accuracy of a balance), the status and likely action is given in Table 5. Following on from this approach, it is clear that several further ISO test methods could be adopted. The general aspects of ISO tests are given in Table 6.

Table 5. AECMA-ISO Harmonisation Review

PROPERTY	AECMA STANDARD	ISO STANDARD	COMMENT	POSSIBLE ACTION
Mass/unit area of pre-preg	EN 2329(G)	ISO 10,352(F)	Good agreement as ISO recently revised using AECMA input , some minor issues. ISO can also replace EN 2557(C).	Modify/Adopt ISO
Volatile content of prepreg	EN 2330(G)	ISO 9782	Good agreement, some minor issues	As above
Resin flow	EN 2332 (G)	ISO 15,034 (F)	ISO document at early stage of development based on ASTM/JIS standard. EN input could produce a better method/standard. Also EN 2560 applicable	AECMA input needed ISO
Test Panel Manufacture	EN 2374(G)	ISO 1268-4(F)	This part of the ISO standard is being prepared using this EN, plus EN 2565 and ISO 9353. No sandwich method in ISO at present. prEN 4177 as replacement for AECMA ENs unlikely now due to withdrawal of German project leader.	ADOPT ISO (Check sandwich laminates covered)
Interlaminar shear strength by short beam bend	EN 2377(G)	EN ISO 14,130	2 mm from EN 2563(C) adopted in EN ISO for all fibres rather than 3 mm but for other thicknesses use scaling rules.	ADOPT ISO

Table 6. General aspects of ISO test method standardisation

Modulus measurement:

0.05% to 0.25% except shear at 0.1% to 0.5% shear strain
(cf ASTM 0.1% to 0.3% tension/0.2% to 0.6% shear)
(cf AECMA P/10 to P/2 where p = peak load)

Tab material:

Default is GRP fabric or cross-ply set at 45 degrees, Square ended tabs of 50mm length in all cases for reduced cost of preparation as in AECMA standards. (cf. ASTM D 3039 allows tab angles from 7 to 90 degrees)

Alternatives can be used providing it is demonstrated that no greater scatter and no lower strength is obtained compared with the default tabs.

8 CONCLUSIONS OF ISO/EN and AECMA STANDARDS COMPARISON

ISO test methods are preferred because:

- they would do most to reduce costs associated with qualification and use of materials, which is particularly severe for composites due to the variety of materials available (ie no "alloy" specification). Alloy specification approach is advocated by users (eg IATA members) and some manufacturers but as the material storage and processing into the structurally useful material is not controlled by the material supplier this is unlikely to be achieved in the near future.
- they represent the highest level of standardisation, to which all countries subscribe and are supported by CEN General Series (Vienna agreement on sharing work and parallel processing), ASTM and JIS. In addition, SACMA have, and ETAC would like to, support the ISO series;
- they are material non-specific where possible, avoiding unnecessary and/or inconsistent duplication and are able to accommodate new materials immediately where technically acceptable - avoiding several years delay in providing a material specific version.
- they avoid unsubstantiated differences between material specific methods,
- a single set of internationally accepted test methods would encourage the development of databases, the introduction and qualification of new material and the use by designers of composites, thereby overcoming major perceived barriers to their use,
- there is increased support and opportunity for experimental validation of test method precision when only one version is available; these validation exercises have not been undertaken widely even in the aerospace industry,
- they reduce the total work load and financial drain on the standardisation system by avoiding duplication or worse of similar (almost identical?) standards. This would aid both standardisation bodies (CEN, BSI, SBAC, ISO etc.) where a recurring theme is the delays occurring in circulating documents and obtaining translations, and the increasing need to ensure their financial viability; and reduce industry's costs by limiting the participation needed by their experts in drafting, meeting attendance etc.

For future developments:-

- AECMA should be more involved in ISO by offering draft of test methods with validation evidence, by providing technical experts and by providing comments during the balloting stages of ISO drafts,
- as well as the comparison of AECMA test methods with ISO tests at the five year review stage, a full analysis should be undertaken of all AECMA standards to accelerate the adoption of ISO test methods,
- AECMA should, following the above review, immediately request ISO to consider the revisions necessary to make the ISO standards acceptable for adoption by AECMA,
- AECMA should concentrate on specification standards related to aerospace applications using the ISO designation (if available) and relating to non-aerospace applications as appropriate,

- ISO should continue to be receptive to modifying and improving their standards, including prior to the five year review (eg ISO 10,352).
- ISO and AECMA should ensure good liaison, which continues to apply for ASTM, EN (General) and JIS.

Some general implications for composites materials for space applications include:

- the out-gassing test is not a major consideration in most other applications (some relevance to composite flywheels),
- smaller diameter, higher modulus fibres would require more care to be taken against local buckling (kinking) in compression, flexure and interlaminar shear tests,
- alignment in tensile test more important due to lower failure strain/high modulus combination.

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31. ASTM D 3518:1994, "In-plane shear stress-strain response of unidirectional reinforced plastics".
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33. EN 2746, Aerospace Series, Glass reinforced plastics - Determination of flexural properties. Three point method".
34. EN ISO/FDIS 14,125 "Fibre-reinforced plastic composites of the flexural properties".
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36. ASTM D790: 1986, "Test methods for flexural properties of unreinforced and reinforced plastics and electrical insulating materials".
37. JIS 7074, "Testing methods for flexural properties of carbon fibre reinforced plastics".
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39. prEN 6033 Aerospace Series, "Carbon fibre reinforced plastics - Test method - Determination of interlaminar fracture toughness energy Mode I".
40. prEN 6034 Aerospace Series, "Carbon fibre reinforced plastics - Test method - Determination of interlaminar fracture toughness energy Mode II".
41. prEN 6035 Aerospace Series, "Fibre reinforced plastics - Test method - Determination of notched and unnotched tensile strength".
42. ASTM D 5766, "Open-hole tensile strength of polymer matrix composite laminates".
43. prEN 6036 Aerospace Series, "Fibre reinforced plastics - Test method - Determination of notched, unnotched and filled hole compression strength".
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46. prEN 6038 Aerospace Series, "Fibre reinforced plastics - Test method - Determination of compression strength after impact".
47. ISO 6603-2, "Determination of multi-axial impact behaviour by the instrumented puncture test".
48. prEN 6043 Aerospace Series, "Thermosetting resin systems- Test method - Determination of gel time and viscosity".
49. ASTM D 3532, Standard test method for the gel time of carbon fibre/epoxy prepreg.
50. JIS K7071, Gel time measurement
51. ISO /CD "Plastics - Prepregs - Gel time".
52. ISO/CD 6721 Part 10, "Plastics -Determination of dynamic mechanical properties - Complex shear viscosity using a parallel plate oscillatory rheometer".
53. prEN 6032 Aerospace Series, "Fibre reinforced plastics - Test method - Determination of the glass transition temperature".
54. prEN 6041 Aerospace Series, "Non-metallic materials - Test method - Analysis of Non-metallic materials (uncured) by DSC".
55. prEN 2559, "Carbon fibre preimpregnates - Test method for the determination of the resin and fibre per unit area".
56. ISO/DIS 11667, "Fibre-reinforced plastics - Moulding compounds and prepregs - Determination of resin, reinforced-fibre and mineral-filler contents - Dissolution method".
57. prEN2962, "Carbon fibre filament yarn (polyacrylonitrile precursor) - Technical specification".
58. ISO/FDIS 13002 Carbon-fibre - Designation
59. ISO/CD 15310, "Reinforced plastic - Determination of in-plane shear modulus by the plate twist method".

APPENDIX A - Recommended Laminate Test Methods

* = UAP vote expected.

MATERIAL PROPERTY	RECOMMENDED METHOD	COMMENTS	AECMA METHODS
Tensile - multidirectional	EN ISO/F-DIS 527-4	Mainly harmonised with ASTM D 3039, some differences still exist. Also suitable for unnotched multidirectional specimen in prEN 6035, which uses a new dumbbell geometry. Replaces ISO 3268 (and equivalents),	
Tensile - unidirectional	EN ISO/F-DIS 527-5	Mainly harmonised with ASTM D 3039, some differences still exist.	prEN2561(C-0°), prEN2597(C-90°), prEN2747 (G)
Compression	EN ISO/DIS-2 14,126	Harmonised with ASTM D 3410, 10% maximum bending strain.	prEN2850
Shear : 45 degree tension	EN ISO/F-DIS 14,130	Harmonised with ASTM D3518, which was the source document. Test now terminated at 5% strain. Warning included on effect of number of shearing planes when using thicker than .125 mm plies.	prEN 6032 1mm thick, all others 2 mm.
Shear modulus : plate twist	ISO/CD 15,310*	Simple procedure for modulus only. On a fast approval route.	
Shear strength : in-plane	ASTM 5379	Preferred for strength, costly for modulus. To be re-drafted and submitted as an ISO method.	
Mode 1 Fracture Toughness	ISO/CD 13,586	Based on ESIS document with USA project leader. Mode 11 being studied in a VAMAS lead project.	prEN6033 (Mode I), prEN6034 (Mode II)
ILSS : through-thickness.	EN ISO/F-DIS 14,129	Standard thickness now 2 mm, scaling available for other thicknesses.	prEN2377 (G), EN2563 (C).
Flexure	EN ISO/F-DIS 14,125	Four point flexure mode added from ASTM/JIS. Four classes of composites with different specimen sizes and spans. Equivalent to ISO 178. Scaling available for non-standard thicknesses.	EN2562 (C), prEN2746 (G)
Fatigue	ISO/CD 13,003	General principles for fatigue aspects included but referencing (in the first place) equivalent static tests for specimen design and jigs.	

MATERIAL PROPERTY	RECOMMENDED METHOD	COMMENTS	AECMA METHODS
Mass per unit area of prepregs.	ISO 10,352*	Aerospace size (100mm x 100mm) and procedures included in 1996 revision.	EN2329 (G), EN2557 (C)
Test and Conditioning Atmospheres	ISO 291*		prEN2743,
Test panel manufacture	ISO 1268*	Multi-part standard, using prEN2565 as main source for Part 4. EN2374 includes sandwich panel. prEN4177 repeats other current work items.	prEN2565 (C), prEN4177, EN2374 (G)
Resin flow of pre-impregnates		Current WD based on ASTM/JIS method	prEN 2560
Carbon fibre designation	ISO/CD-2 13,002*	Both ISO and prEN standards will reference the ISO test methods.	prEN 2962
Open hole tensile	ISO NWI	NPL has prepared a draft of this method based on EN ISO 527-4. and ASTM D 5766. (see section)	prEN 6035
Filled/open hole compression	ISO NWI	NPL has prepared a draft of this method based on EN ISO 14,125	
Pin-bearing	ISO NWI	NPL has drafted a method using a common size that is the subject of an ISO new work proposal.	prEN 6037
Analysis of uncured by DSC	ISO	SC5 of ISO are working on DSC methods. Sc13 has put its own work in abeyance awaiting outcome of SC5 work. Expected if required to write an "annex" for this standard covering the use with composites.	
Gell time	ISO	ISO currently using ASTM D3532 and JIS K7071 for a Japanese prepared draft, This is an basic test using drawing of a resin with a glass rod. A more reliable test would improve the standard.	prEN 6041

APPENDIX B - ISO TC61/SC13 CURRENT WORK PROGRAMME AT 28/9/96

[Code NC=no change, PUB=published, DIS= draft international standards(F-DIS=formal DIS), CD=committee draft, ISC=confirmed international standard, WDR=withdrawn]

ITEM	TITLE	STATUS
472	CD 13002.2 Carbon fibres - Designation system for filament yarns.	DIS
609	NWP 13922 Vocabulary - Reinforcements and composites.	CD
200C	DIS 1889 Reinforcement fibres - Determination of linear density.	NC
201B	DIS 1890 Reinforcing yarns - Determination of twist.	NC
291B	DIS 3344 Reinforcement products - Determination of moisture content.	NC
365C	DIS 4602 Reinforcements - Woven fabrics - Determination of number of yarns per unit length of warp and weft.	NC
368B	DIS 5025 Reinforcement product - Woven fabrics - Determination of width and length.	FDIS
369C	CD 4605 Reinforced products - Woven fabrics -Determination of mass per unit area.	CD2
199B	DIS 1888 Textile glass - Staple fibres or filaments - Determination of average diameter.	NC
247B	ISO 2559.1980 Textile glass - Mats (made from chopped or continuous strands) - Basis for a specification.	CD
293B	CD 3374 Textile glass mats - Determination of mass per unit area.	WDR
295B	CD 3341 Textile glass - Yarns - Determination of breaking force and breaking elongation.	DIS
316B	NWP 3616 Textile glass - Mats - Determination of average thickness, thickness under load, and recovery after compression.	NC
364B	ISO 2797 Textile glass - Rovings - Basis for a specification.	ISC
444	ISO 8516:1987 Textile glass - Textured yarns - Basis for a specification.	ISC
556	CD 12113 Plastics - Thin textile glass fabrics - Determination of thickness (< 100 mm)	WDR
663	NWP 15039 Glass reinforcement fibres - Measurement of the solubility of the sizing in acetone - Flask method.	NC
664	NWP 15100 Reinforcement fibres - Chopped strands - Determination of bulk density.	NC
665	NWP 15101 Reinforcement fibres - Chopped strands - Determination of long strands by visual observation.	NC
523	ISO 10120:1991 Carbon fibre - Determination of linear density.	ISC
	DIS 10618 Carbon fibre - Determination of tensile properties of resin-impregnated yarns.	
528	ISO 11566:1996 Carbon fibre - Determination of tensile properties of single-filament specimens.	PUB
492	DIS 12114 Fibre-reinforced plastics - Thermosetting moulding compounds and prepregs - Determination of curing characteristics.	FDIS

ITEM	TITLE	STATUS
494	DIS 11667 Fibre-reinforced plastics - Moulding compounds and prepregs - Determination of resin, reinforced-fibre and mineral-filler contents - Dissolution method.	FDIS
535A	DIS 10352 Fibre-reinforced plastics - Moulding compounds and prepregs - Determination of mass per unit area.	NC
563	DIS 12115 Fibre-reinforced plastics - Thermosetting moulding compounds and prepregs - Determination of flowability, maturation and shelf life.	FDIS
615	NWP 14127 Composites - Determination of the resin and fibre content for composites reinforced with carbon fibre.	CD
616	NWP 14128 Composites - Reactivity of carbon prepregs.	CD
175B	DIS 1172 Textile glass reinforced plastics, prepregs, moulding compounds and composites and laminates - Determination of the textile-glass and mineral-filler content - calcination method.	PUB
443	ISO 8515:1991 Textile glass reinforced plastics - Determination of compressive properties in the direction parallel to the plane of lamination.	ISC
446	DIS 9163 Textile glass - Rovings - Manufacture of test specimens and determination of tensile strength of impregnated rovings.	PUB
448	DIS 9291 Textile glass reinforced plastics - Rovings - Preparation of unidirectional plates by winding.	PUB
546	WD 13003 Bending fatigue test for reinforced plastics ~~on unsecured test pieces (embedded or not)~~ .	NC
59B	ISO 1268 Composites and reinforced plastics - Test plate manufacturing methods - Part 1: General conditions.	DIS
603	DIS 14125 Fibre-reinforced plastic composites - Determination of flexural properties.	NC
611	DIS 14129 Fibre-reinforced plastic composites - Determination of in-plane shear modulus and strength by plus or minus 45 degrees tension test method.	NC
612	DIS 14130 Fibre-reinforced composites - Determination of apparent interlaminar shear strength by short-beam method.	NC
617	DIS 14126 Fibre-reinforced plastic components - Determination of compressive properties in the in-plane direction.	NC
681	NWI 15310 Fibre reinforced plastic composites - Determination of in-plane shear modulus by plate twist method.	NC

APPENDIX C - CEN TC249/SC2 CURRENT WORK PROGRAMME

CEN	TITLES	UAP	Parallel Vote	Transfer ISO
	REINFORCEMENTS			
216	Textile glass yarn - Specification (P3)			
217	Chopped strands - Specification (P3)			
218	Glass products - Designation (P1) (UAP on ISO 2078)	X		
219	Carbon fibres - Designation (P1) (Subject ISO N472) = CD 13002		X	
220	Reinforcements - Determination of linear density of textile glass, carbon fibres aramid fibres and possibly other reinforcing (ex prEN 1180) → (ISO 1889)			
221	Reinforcement - Determination of twist of textile glass, carbon and aramid yards (ex prEN 1181) → (ISO 1890)			
227	Reinforcement fibres - Determination of moisture content (ex prEN 1182) → (ISO 3344)			
222	Carbon fibre - Tensile properties of resin impregnated yarns (Vote // on ISO 10618)		X	
300	Textile glass rovings - Test specimens and tensile strength (UAP on ISO 9163)	X		
223	Carbon fibres - Determination of size content (UAP on ISO 10548)	X		
224	Reinforcement fibres - Sampling plans applicable to received batches (UAP on ISO 1886) → EN 1886	X		
225	Glass woven fabrics - Specification (P3)			
226	Woven fabrics (carbon, glass, aramid) - Désignation (P1)			
291	Carbon yarns - Specification (P3)			
292	Carbon fabrics - Specification (P3)			
293	Amid yarns - Specification (P3)			

CEN	TITLES	UAP	Parallel Vote	Transfer ISO
	PREIMPREGNATES - UD REINFORCED THERMOSETS			
228	Thermoset prepregs with oriented reinforcements "Specification for preimpregnated fabrics and UD tapes" (P3)			
229	Thermoset prepregs with oriented reinforcements "Specifications for composites" (P3)			
230	Thermoset composites with oriented reinforcements "Designation" (P1)			
231	Thermoset composites with oriented reinforcement "Preparation of plates or panels for test purposes"			
234	Thermoset prepregs with oriented reinforcements - Exothermic behaviour			
232	Thermosets prepregs with oriented reinforcements - Drapability			
233	Thermoset prepregs with oriented reinforcements - Tackiness			
235	Prepregs and randomly reinforced compounds - Determination of linear shrinkage = prEN 1842			
236	Prepregs and composites, randomly reinforced thermosets - Determination of the mean fibre length			X
237	Fibre reinforced composites - Determination of fibre wetting in SMC			
238	Fibre reinforced composites - Determination of surface waviness			
239	Fibre reinforced composites - Preparation of test plates by press moulding (issue of ISO 1268 in 9 Parts)			
240	SMC - Specifications (P3)			
241	BMC - DMC - Specifications (P3)			
242	SMC - Designation (P1)			
243	BMC - DMC - Designation (P1)			
244	Prepregs - Mass per unit area (ISO 10352) (= UAP)			X
294	SMC - Flowability, maturation, shelf life (ISO/DIS 12115)		X	
295	SMC - Curing characteristics (ISO/DIS 12114)		X	

CEN	TITLES	UAP	Parallel Vote	Transfer ISO
	REINFORCED THERMOPLASTICS			
252	Designation of GMT for polypropylene (P1 - General)			
	GMT (P) Method of test			
253	Specification of GMT (P3) (Glass reinforced mat T with P)			
254	Test method for the determination of flowability for GMT (2 Parts) (similar to subjects 294-295)			
296	Specification for UD filament, reinforced thermoplastic sheet (P1, P, P3)			
297	Specification for fabrics, UD, reinforced plastics (P1, P, P3)			
	TEST METHODS			
245	Plastics - Determination of tensile properties - UD Composites (EN ISO 527 Part 5)		X	
2	Plastics - Tensile properties - Test conditions of ISO and orthotropic composites (EN ISO 527 Part 4)		X	
246	Determination of flexural properties of reinforced plastics/composites (EN ISO 14125)		X	
247	Determination of compression properties of reinforced plastics/composites (EN ISO 14,126)		X	
248	Determination of interlaminar shear strength of reinforced plastics/composites (EN ISO 14,130)		X	
251	Determination of in plane properties by +45° tension test of reinforced plastics/composites (EN ISO 14,129)		X	
309	Textile glass reinforced plastics, prepregs, moulding compounds and composites _ Determination of glass and filler content - Method of calcination - (ISO 1172)	X		
250	Textile glass reinforced plastics - Determination of void content (UAP on ISO 7822)	X		
310	Fibres reinforced plastics - Moulding compounds and prepregs - Determination of fibre, resin and filler content - Method by dissolution (ISO/CD 11667)	X		
	PULTRUDED PROFILES			
	Designation/Specifications Parts 1-3			

APPENDICES D - AECMA C7/WG5 WORK PROGRAMME

prEN Nb responsibility	Title
EN 2329 SBAC	Test method for the determination of mass per unit area of woven textile glass - Fibre fabric preimpregnate
EN 2330 SBAC	Test method for the determination of the percentage of volatile matter in woven textile glass - Fibre fabric preimpregnate
EN 2331 SBAC	Test method for the determination of the determination of the resin content of woven textile glass - Fibre fabric preimpregnate
EN 2332 SBAC	Test method for the determination of the resin flow of woven textile glass - Fibre fabric preimpregnates
EN 2374 SBAC	Glass fibre reinforced mouldings and sandwich composites - Production of test panels
EN 2375 SBAC	Resin preimpregnated materials - Production batch sampling procedure
EN 2377 SBAC	Glass fibre reinforced plastics - Test method - Determination of interlaminar shear properties
EN 2378 SBAC	Fibre reinforced plastics - Determination of water absorption by immersion in demineralised water
EN 2489 SBAC	Fibre reinforced plastics - Determination of the action of liquid chemicals
EN 2557 SBAC	Carbon fibre preimpregnates - Test method for the determination of mass per unit area
EN 2558 SBAC	Carbon fibre preimpregnates - Test method for the determination of the percentage of volatile matter
EN 2559 SBAC	Carbon fibre preimpregnates - Test method for the determination of the resin and fibre per unit area
prEN 2560 BNAE	Carbon fibre preimpregnates - Test method for the determination of the resin flow
EN 2561 SBAC	Carbon-thermosetting resin unidirectional laminates - Tensile test parallel to the fibre direction
EN 2562 SBAC	Unidirectional - laminates - Carbon - thermosetting resin - Flexural test
EN 2563 SBAC	Carbon - thermosetting resin unidirectional laminates - Test method - Determination of apparent interlaminar shear strength
prEN 2564 BNAE	Carbon fibre laminates - Test method for the determination of the fibre and resin fractions and porosity content
prEN 2565 SBAC	Preparation of carbon fibre reinforced resin panels for test purposes
prEN 2597 BNAE	Carbon thermosetting resin unidirectional laminates - Tensile test perpendicular to the fibre direction
prEN 2743 BNAE	Reinforced plastics - Standard atmospheres for conditioning and testing
prEN 2745 SBAC	Reinforced plastics - Method for determination of density
prEN 2746 BNAE	Glass fibre reinforced plastics - Determination of flexural properties - Three point bend method
prEN 2747 BNAE	Glass fibre reinforced plastics - Determination of tensile properties

prEN Nb responsibility	Title
prEN 2823 BNAE	Fibre reinforced plastics - Test method for the determination of the effect of exposure to humid atmosphere on physical and mechanical characteristics
prEN 2823 SBAC	Fibre reinforced plastics - Test method for the determination of the effect of exposure to humid atmosphere on physical and mechanical characteristics
prEN 2833-1 SBAC	Glass fibre thermosetting preimpregnates - Technical specification - Part 1 : General
prEN 2833-1 SBAC	Glass fibre thermosetting preimpregnates - Technical specification - Part 1 : General
prEN 2833-2 SBAC	Glass fibre thermosetting preimpregnates - Technical specification - Part 2 : Glass fabric / Epoxy resin preimpregnates curing at up to 125 °C for continuous use up to 80 °C
prEN 2833-3 SBAC	Technical specification glass fibre thermosetting preimpregnates - Part 3 : Qualification/Batch release requirements fabric reinforced epoxy resin cured at up to 180 °C for continuous use up to 120 °C
prEN 2833-4 SBAC	Technical specification glass fibre thermosetting preimpregnates - Part 4 : Qualification/Batch release requirements unidirectional reinforced epoxy resin cured at up to 125 °C for continuous use up to 80 °C
prEN 2833-5 SBAC	Technical specification glass fibre thermosetting preimpregnates - Part 5 : Qualification programme and batch release testing of glass fabric reinforced phenolic resin preimpregnates for aircraft interiors
prEN 2833-6	Glass fibre thermosetting preimpregnates - Technical specification - Part 6 : Glass fabric/epoxy resin preimpregnate curing at up to 180 °C for continuous use to 130 °C
prEN 2850 SBAC	Carbon fibre thermosetting resin unidirectional laminates - Compression test parallel to the fibre direction
prEN 2850 SBAC	Carbon fibre thermosetting resin unidirectional laminates - Compression test parallel to the fibre direction
prEN 2962 SBAC	Carbon fibre filament yarn (polyacrylonitrile precursor) - Technical specification
prEN 2963 BNAE	Carbon fibres - High strength carbon fibre yarns - Tensile of strength 3900 MPa, module tensile test 235 GPa - Elongation at rupture 1.4% - 800 tex f 12000 - Fibre class F4
prEN 2964 SBAC	Carbon fibre filament yarn - Test method for the determination of the mass per unit length
prEN 2965 SBAC	Carbon fibre filament yarn - Test method for the determination of the fibre diameter and the shape of the cross section
prEN 2966 SBAC	Carbon fibre filament yarn - Test method for the determination of the twist
prEN 2967 SBAC	Carbon fibre filament yarn - Test method for the determination of the size content
prEN 3075 SBAC	Reinforcement fibres for plastics - Tensile test of impregnated yarn test specimens
prEN 3076 SBAC	Carbon fibre filament yarn - Test method for the determination of the density
prEN 3615 BNAE	Fibre reinforced plastics - Test method for the determination of the conditions of exposure to humid atmosphere and the determination of moisture absorption

prEN Nb responsibility	Title
prEN 3615 SBAC	Fibre reinforced plastics - Test method for the determination of the conditions of exposure to humid atmosphere and the determination of moisture absorption
prEN 3616 SBAC	Fibre reinforced plastics - Test method for the determination of moisture content by means of moisture evolution analyser (MEA)
prEN 3675 SBAC	Statistics for sampling for the acceptance testing of aramid, carbon and textile glass filament yarn
prEN 3675 SBAC	Sampling plan for acceptance testing of aramid carbon fibre and textile glass filament yarns
prEN 3783 BNAE	Procedure of the normalisation of tests results of fibre dominated composite mechanical properties
prEN 4177-1 SBAC	Fibre reinforced molded half-finished products - Preparation of test panels of yarns and rovings unidirectional winding
prEN 4177-2 SBAC	Fibre reinforced molded half-finished products - Preparation of test panels of plane reinforcement products
prEN 4177-3 SBAC	Preparation of honeycomb/prepreg sandwich test panels
prEN 4238 SBAC	Fibre reinforced plastics - Determination of the effect of dry heat on physical and mechanical characteristics
prEN 6030 SBAC	Fibre reinforced plastics - Determination of mechanical degradation due to chemical paint stripper
prEN 6031 SBAC	Fibre reinforced plastics - Determination of in-plane shear properties (45° tensile test)
prEN 6032 SBAC	Fibre reinforced plastics - Determination of the glass transition temperatures
prEN 6033 SBAC	Carbon fibre reinforced plastics - Determination of interlaminar fracture toughness energy - Model 1 - G_{1c}
prEN 6034 SBAC	Carbon fibre reinforced plastics - Determination of interlaminar fracture toughness energy - Model 2 - G_{2c}
prEN 6035 SBAC	Fibre reinforced plastics - Determination of notched and unnotched tensile test
prEN 6036 SBAC	Fibre reinforced plastics - Determination of filled hole and unnotched compression test
prEN 6037 SBAC	Fibre reinforced plastics - Determination of bearing strength
prEN 6038 SBAC	Fibre reinforced plastics - Determination of compression strength after impact
prEN 6039 SBAC	Fibre reinforced plastics - Determination of the exothermic reaction during curing or prepreg materials
prEN 6060 SBAC	Non-metallic materials - Analysis of thermoset systems by high performance liquid chromatography (HPLC)
prEN 6041 SBAC	Non-metallic materials - Analysis of non-metallic materials (uncured by differential scanning calorimetry (DSC))
prEN 6042 SBAC	Analysis of organic compounds by infrared spectroscopy
prEN 6043 SBAC	Fibre reinforced plastics - Determination of gel time and viscosity of matrix resins
prEN 6044-1 SBAC	AIMS - Carbon fibre reinforced epoxy prepreg

prEN Nb responsibility	Title
prEN 6044-2 SBAC	AIMS - Carbon fibre reinforced epoxy prepreg
prEN 6060 SBAC	Fibre reinforced plastics - Test method - Determination of the tensile single lap shear strength
prEN 6061 SBAC	Fibre reinforced plastics - Test method - Determination of sandwich flexural strength 4 point bending
prEN 6062 SBAC	Fibre reinforced plastics - Test method - Flatwise tensile test of composite sandwich panel
prEN 6063 SBAC	Fibre reinforced plastics - Test method - Determination of material degradation due to chemical products
prEN 6064 SBAC	Non-metallic materials - Analysis of non-metallic materials (cured) for the determination of the extent of cure by Differential Scanning Calorimetry (DSC)
prEN 6066 SBAC	Fibre reinforced plastics - Test method - Determination of tensile strength of a tapered and stepped joints