



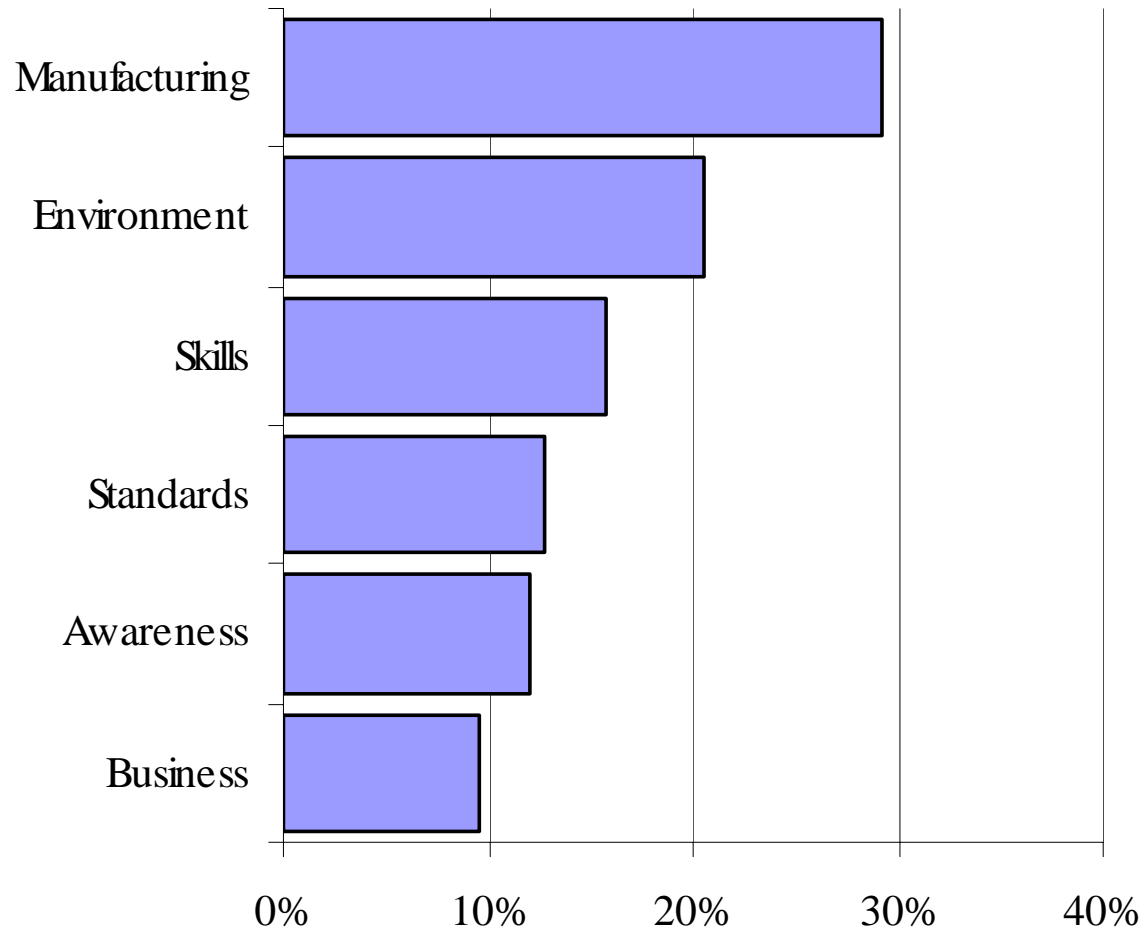
National Physical Laboratory

National Composites Network

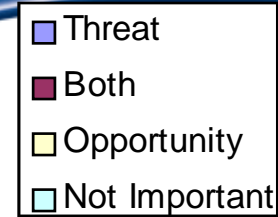
Standards, Testing and Design

Graham D Sims and Bill Broughton

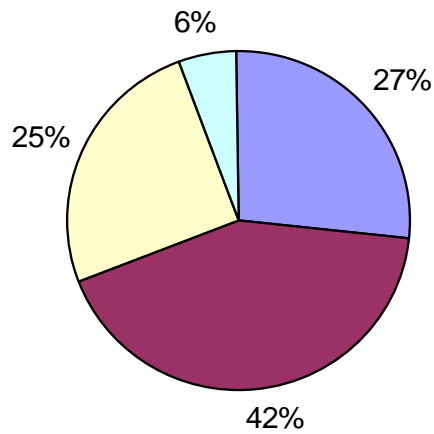
Issues facing the industry – standards 4th most important



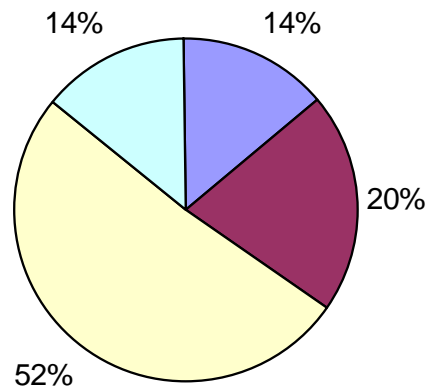
Issues scoring – standards biased towards optimism



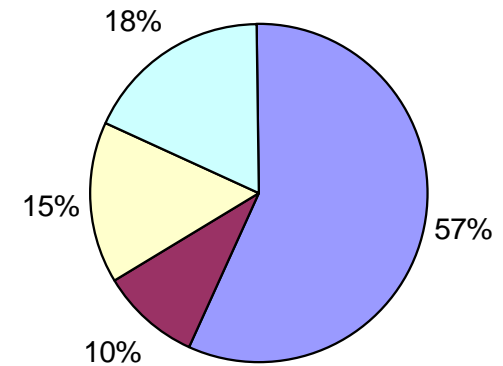
Impact of the Environmental Issue



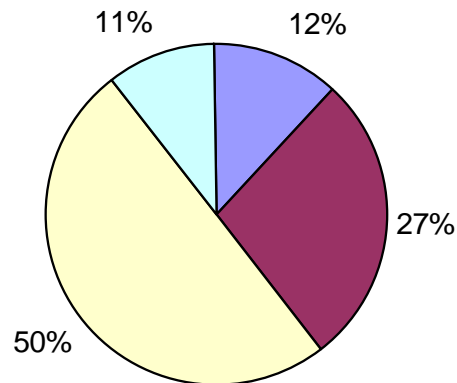
Impact of Cost-effective Manufacturing



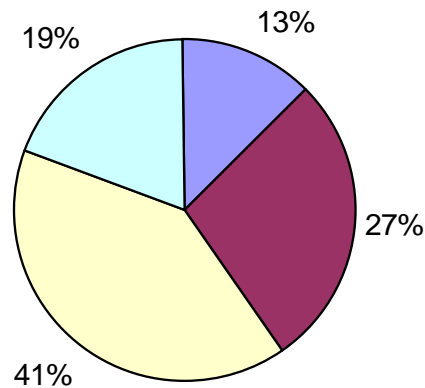
Impact of Skills Shortages



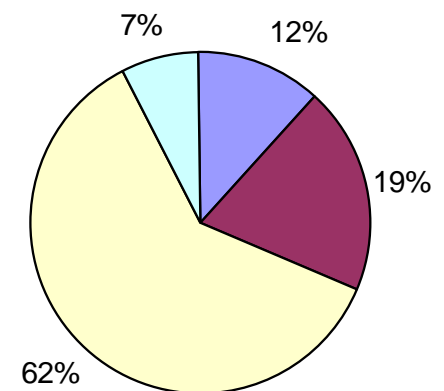
Impact of Standardisation



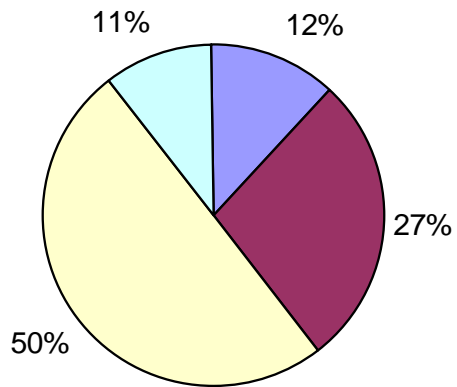
Impact of other Business Issues



Impact of Education and Awareness



Standardisation – was of concern for the longest



- Threat
- Both
- Opportunity
- Not Important

Figure A5.25:
Percentage of
Business Affected
(%)

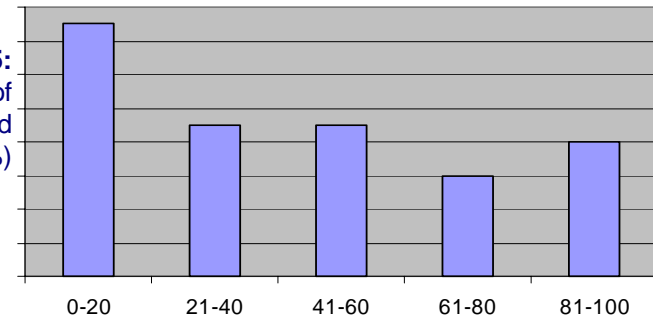


Figure A5.26:
Timescale for the
Issue to have
Maximum Effect
(Years)

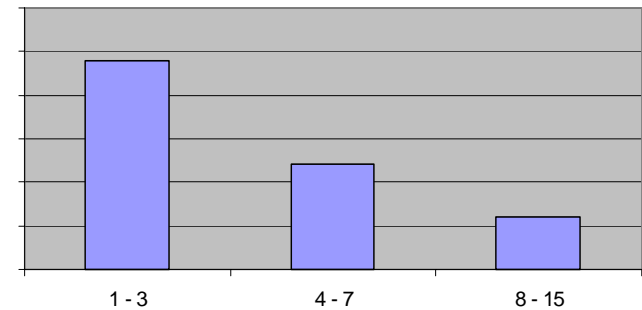
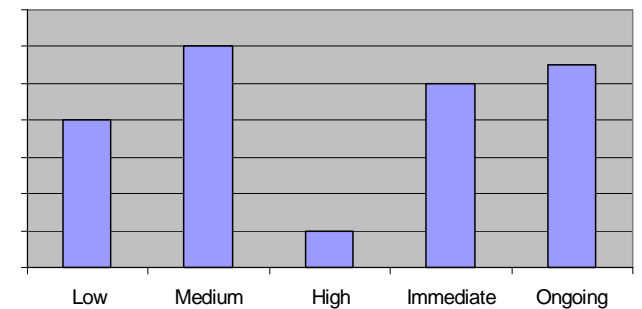


Figure A5.27:
Company's
Action Priority
for the Issue



Issues

Standards and Design Codes

- Concentration of working with suppliers meeting standards
- Coordination of standards activities in different countries
- Improved general guidance and codes until standards arrive

Awareness and Education

- Concentration on teaching composites in core modules of engineering courses
- Development of design codes
- Support for the Trade Associations

Foresight Recommendation - 1

Bring about a step-change in standards for composites

- Task: Specify and publicise international quality and technical standards to address the general lack of standards and codes for composite materials and products.
- Action: Trade and professional associations facilitating dialogue with regulators.

Recommendations

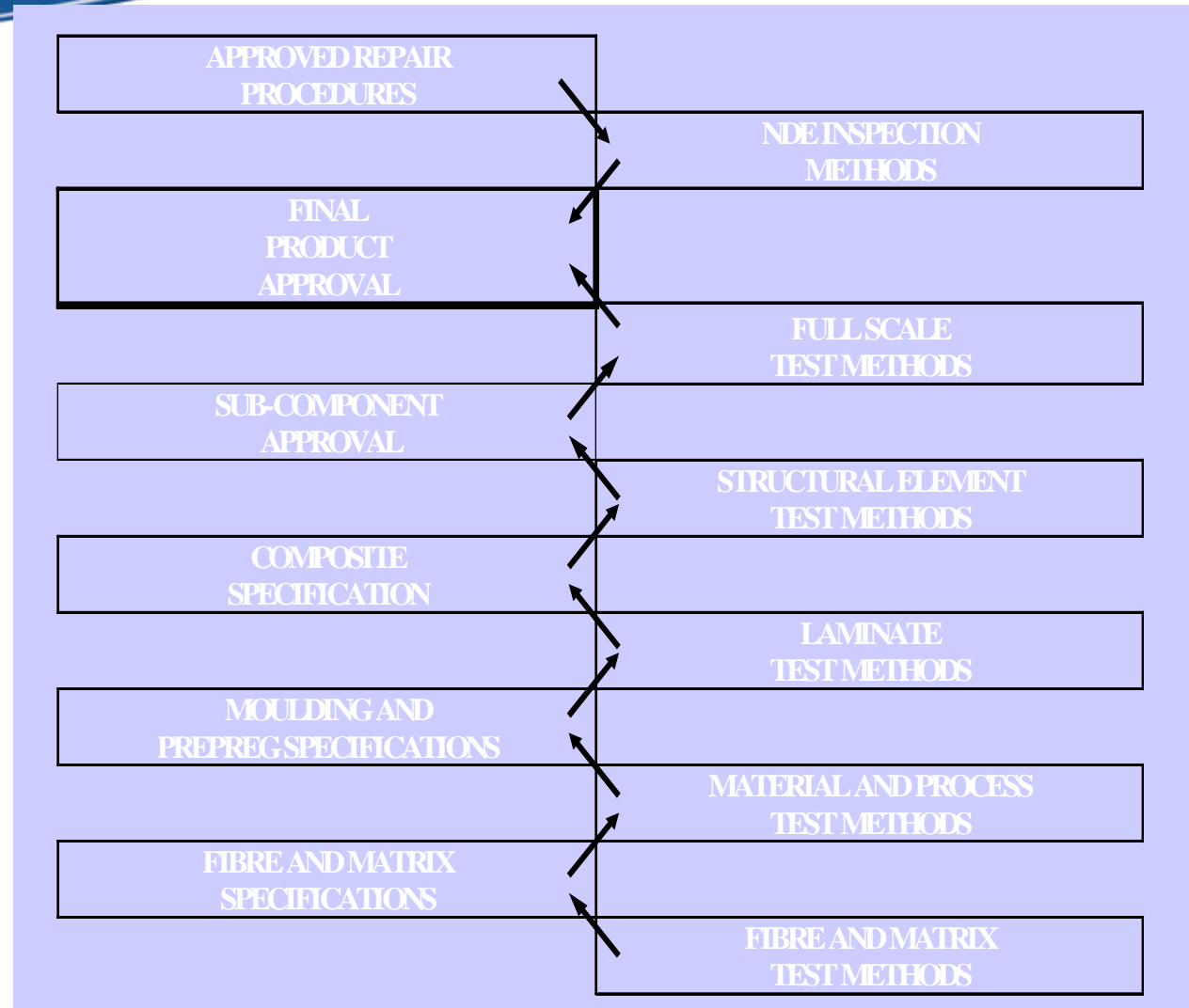
Standards and Design Codes

- To demonstrate the increasing availability of standards in a maturing industry, companies should require that suppliers work to international quality and technical standards wherever possible (e.g in material specifications, in ITT for supply).
- The industry, in conjunction with end-users and standards development organisations (eg British Standards Institution, NPL and BPF) should further develop design codes to facilitate greater use of composites. These codes will also provide the information needed in training engineers.

Recommendations (cont.)

- Additionally, the industry should also work with end-user groups to develop and publicise guidance information, as a faster pre-cursor to standardisation. The future conversion of these guides to standards should then be proactively undertaken with DTI materials measurement and innovation budget support.
- International coordination of standards should also be targeted by the industry, to enhance the UK's ability to export.
- The CPA and BPF could develop their industry guidance documentation by collating and disseminating information relating to composites. They could further develop guidelines to encourage users to make use of accredited suppliers that comply with industry standards.

Design Validation Chain - each specification level needs supporting test methods



National Physical Laboratory

- NPL is responsible for primary standards as main holder of UK National Measurement System
- 75% DTI Materials Measurement programme as a proxy customer for UK industry - particularly SMEs
- 25% Consultancy, Testwork, Equipment and Software sales (e.g. CoDA preliminary design and material synthesis)
- NPL Materials Centre covers metals, plastics, composites, ceramics, tools steels, rubbers, sensor materials, thermodynamics, etc.
- 10 Composites staff (materials technologists, mechanical and aeronautical engineers, physicists, polymer chemists, applied mathematicians) on PMC, MMC and CMC
- Full range of mechanical, phys-chemical, NDE, analysis (FEA) facilities

NPL represents the UK in standards activities

- ISO TC61/SC13 - Principle UK delegate on composite test methods. Project leader for 12+ projects in SC2/SC5/SC13
 - Convenor SC2/WG5 – Thermal properties
- CEN TC 249/SC2 - Principle UK delegate on laminates.
 - Convenor WG5 Test Methods
 - Convenor WG6 Pultrusions
- BSI Committees
 - PRI 21/-/6 Mechanical Properties
 - PRI 42 Composites
 - ACE 64 Aerospace Composites
 - PRI 1/-/1 International committee
- ISO TC67/ GRP Piping – Offshore (now published as ISO 14692)
- AECMA (CEN Aerospace) – previously WT4 on Phys.chem. test methods
- ASTM D30 member/International harmonisation group
- BPF/Composites Group, previously Standards Strategy Coordinator
- VAMAS (G8) TWA5 Polymer Composites - International Chair

Standards drafted by NPL

- BS EN ISO 527- 4 Tension - "Isotropic materials" - ASTM D 3039
- BS EN ISO 527 - 5 Tension - "Unid. materials" - ASTM D 3039
- ISO 1268-4 Manufacture of test plates from pre-preg
- ISO 6721 Tg by DMA + temperature calibration reference material
- BS EN ISO 14125 Three and four point flexure - ASTM D 790
- BS EN ISO 14126 Compression - ASTM D 3410
- BS EN ISO 14129 In-plane shear by $\pm 45^\circ$ tension - ASTM D 3518
- BS EN ISO 14130 Interlaminar (short beam) shear - ASTM D 2344
- ISO 10350-2 Single Point composites database
- ISO 13003 Fatigue –General principles
- BS EN ISO 15310 Shear modulus by plate twist
- ISO 15024 Mode I fracture Toughness (Final edit only)

NPL work ready for standardisation

- ISO NWI Open-hole tension
- ISO NWI Open/filled hole compression
- ISO NWI Pin-bearing test

- ISO NWI Double notch interlaminar shear strength
- ESIS Mode II fracture energy
- NPL draft Through-thickness compression
- NPL draft Through-thickness tension

- NPL draft Elastic constants by ultrasonics
- NPL draft for Ultrasonic C-scan inspection (3 parts)
- NPL GPG on a Standard Qualification Plan (prepregs now, bit other sectors requesting)

In most cases a good quality draft and precision data exist

Materials Solutions Polymer Composites

[Tools](#)
[About](#)
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[Feedback](#)
[Links](#)

Materials Solutions provides answers to problems associated with materials measurement, test methods and standards materials usage, material characterisation.

The information on this site arises mainly from research funded by the Engineering Industries Directorate of the UK Department of Trade and Industry. The information is supplied by contractors to DTI.

VIRCON	Measurement Advice	MATDAT	EngSol	Project Explorer
Provides information and guidance on all aspects of polymer composites for both experienced users and newcomers.	Guidance on testing composites, selecting standards, standardisation activities, measurement expertise and publications.	Classified database of property data (mechanical, thermal, electrical)	Engineering guidance on design of composites materials.	Quickly determine the content and relevance of completed materials projects.
Use tool...	Use tool...	Use tool...	Use tool...	Use tool...

Not sure which tool you need? [Select this link](#) for assistance.

Standards selector with
direct link to BSI on this
partner built web site

www.materialssolutions.info



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Polymer Composites

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Recommended Standard

BS EN ISO: 11357

Part: 1

Published: 1999

Contact: [BSI](#)

Title

Plastics - Differential Scanning Calorimetry - General principles

Scope

This international standard specifies general principles of differential scanning calorimetry like description of the principle and apparatus, sampling, calibration and general aspects of the procedure and test report common to all following parts. Details on performing distinct determinations for special methods are given in subsequent parts of this international standard.

Comment

This method is suitable for comparative measurements on polymeric materials. However, the results obtained may be influenced by systematic errors such as incorrect calibration, baseline correction, specimen conditioning and preparation etc. It is strongly recommended to establish polymeric reference materials (similar to those materials routinely analysed) for comparative analysis parallel with the materials being tested. This allows for comparison of data obtained from different laboratories, instruments, test dates, specimen conditioning and preparation procedures etc.

NPL has been running a series of Department of Trade and Industry funded projects in collaboration with industry and interlaboratory tests have been conducted in both DSC and DMA techniques. For more information in the Thermal analysis projects, contact coil@npl.co.uk. See also under ""Introduction to testing composites""

Alternative Standards

prEN 6041, ASTM E 473, ASTM E 1953

Related Publications

Related publications go here...

Next level – final product specification

EN 13706 - Reinforced Composites - Specification For Pultruded Profiles

- Part 1 - Designation
 - Code: Pultrusion, EN 13706 - B G V, I F, E23
- Part 2 - Methods of test and general requirements
 - dimensional tolerances, defect levels, mandated tests, other recommended tests, QA aspects
- Part 3 - Specific requirements
 - specific grades, E23 and E17, with mandated requirements based on EN ISO test methods (as previous slides)
- Further work
 - Fire performance – agreement obtained with EU fire regulators
 - Weathering to chemical performance – further information needed

Recently product standards and codes reviewed

- GRP pressure vessels –prEN 13121
- GRP piping offshore – ISO14692
- GRP Water piping – BS 7159/6464
- GRP Water tanks – BS EN 13280
- Lloyd's Register:- Special service Craft
- DNV - High Speed and Light Craft
- Commercial Aircraft Certification
- Military Handbook 17
- Wrapped Gas Cylinder–EN 12445/EN12447/ISO 11119 (3 parts)
- UK Defence standard 0933
- Access Engineering – EN14122
- FRP Lighting Columns – EN 40-7
- GRP Rockbolts – BS 7861
- Inspection Chambers – BS 7158
- EUROCOMP Design Guide

Aspects reviewed in each document

- Constituent materials
- Laminate test methods
- Materials properties - default
- Materials properties - measured
- Temperature capability
- Water absorption
- Chemical resistance
- Impact resistance
- Creep behaviour
- Fatigue and damage behaviour
- Static electricity
- Flammability
- Production control
- Cure assessment
- Non-destructive testing
- Tolerances
- Defects
- Approval of laminators
- Handling, storage and packaging
- Repair and maintenance

Future measurement research

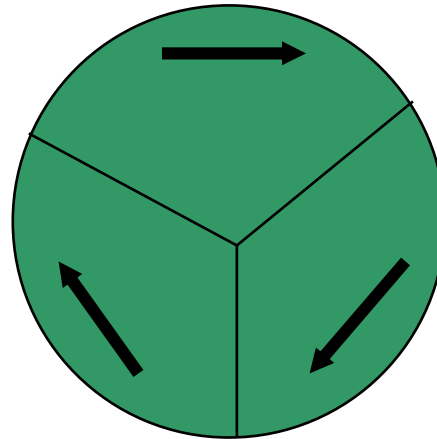
- DTI National Measurement Systems Directorate is main sponsor of research on measurement methods and standards in the UK
- Range of programmes including materials
 - Acoustics
 - Bio-technology
 - Dimensional measurement
 - Air quality
 - Mass & force
 - Materials
 - Nano-technology
 - Thermal
 - Photonics
 - Photometry/colour
 - Pressure
 - RF/microwaves
 - Radiometry
 - Scientific software
 - Time
 - Emerging technologies
- Materials endeavour in three phases; Processing, Characterisation and Performance
- Agreed programme arises through the “formulation” process.

Life-cycle Approach for materials endeavour

Measurements for Materials

Processing

/ Manufacturing / Fabrication / Recycling



Measurements for Materials

Performance

/ Service performance / Multi-point data / Whole life costs

Measurements for Materials

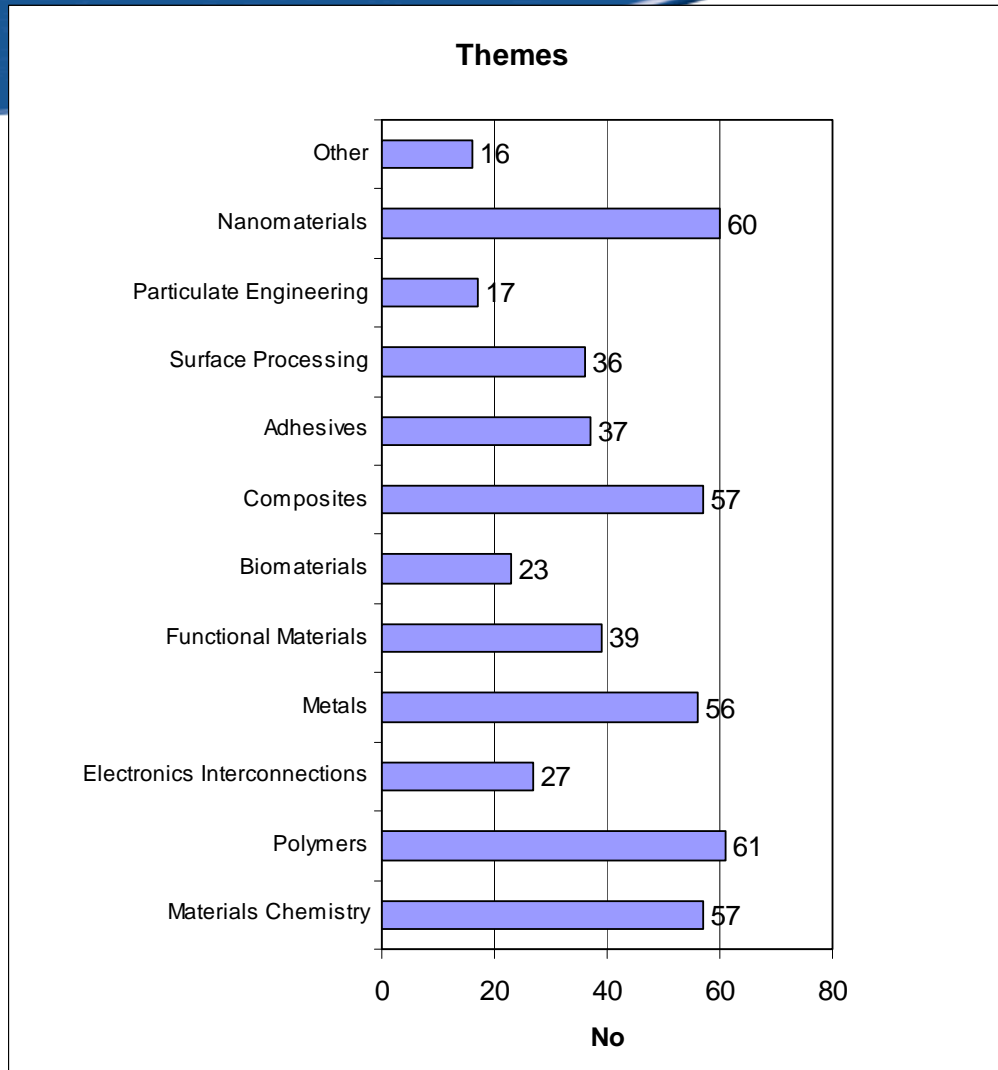
Characterisation

/ Microstructure / Initial properties / Single-point data

Programme Formulation: Processing

- **Initial input**
 - Input from web survey – many quotes, good support
 - Input from DTI Foresight
 - Input from Industrial Advisory Group
- **Projects formulated – advertised on web**
 - Web scored (weighted)
- **Prioritisation workshop at DTI**
 - Projects priority G2, G3 (and G1) (higher weighted)
- **Measurement Advisory Group for Materials WG decision (main decision)**
 - Only metals people present , no polymer or composites person
 - G2 Cure monitoring not selected not selected – so no composites processing project!
 - c.f. £30m National Composites Network and Foresight highlighting manufacturing as industries principle concern

Areas of work - Initial web replies



1500 recipients by letter and e mail

Drawn up from lists supplied by theme leaders
130 positive replies

~3.5 areas/response

74 responses.
52 (~70%) highlighted environmental and other Legislation

Initial web survey - comments received

G2	Comments	Type
Cure related	<i>Cure mechanisms</i>	Major
	<i>Curing and control of exothermic reactions</i>	
	<i>Tg of resins for low-temperature cures (repair)</i>	Acad.
	<i>on-line cure monitoring</i>	SME
	<i>energy efficient processing</i>	RTO
	<i>monitoring for on-line process control</i>	
	<i>low cost manufacture</i>	Major
	<i>state of cure</i>	SME
	<i>repeatable cure</i>	
	<i>phenolic/polyester cure control</i>	Major
<i>degree of cure/resin viscosity</i>	Acad.	
<i>state of cure</i>		
<i>glass transition temperature</i>	SME	

Polymer Composites and Adhesives proposals

- G1: Physical Test Methods for Improved Quality Control and Prediction of Composites Processing.
- G2: Traceability, Optimisation and Impact of Cure Process Assessment
- G3: Adhesive Bonding Measurements for Quality Control and Process Optimisation
- G4: Reliability of Styrene Measurements for Open Mould Processing
- G5: Optimisation of Fusion Bonding for Thermoplastic Based Polymer Matrix Composites
- G6: Measurement of Exfoliation in Clay-Based Nanocomposites

G2-Traceability, Optimisation and Impact of Cure Process Assessment

Technical Issues

- Traceability of monitored data (e.g. dielectrics, ultrasonics) to the actual chemical cure state
- Confirmation for wider range of materials of the relationship between DSC and DMA measurements of T_g
- To assess the effect of optimised and non-optimised cure conditions on final properties and component performance.

Possible Outputs

- Data relating cure state with measured output data (i.e. T_g is a symptom but not the chemical cure state)
- Good Practice Guidance and draft test methods

Impact

- Improved process control and process optimisation
- Reduced energy costs

Conclusions

- Excellent progress has been made in developing an infrastructure for composite material properties based on international test methods,
- Composite materials data for design etc. must be obtained using standard test methods on well - characterised materials.
- Database formats for materials selection data and procedures for easier qualification are available,
- Need to encourage adoption of standards in product specifications, Invitations to Tender, or to facilitate compliance with EU directives,
- Design procedures and codes now needing most attention, which will result in new test method requirements e.g. input data and model output validation,
- Guidance needed also on installation/handling/ maintenance/repair,
- To ensure future measurement projects undertaken the industry needs to be well represented at all stages of programme formulation.