

Reference Temperature for Thermal Testing of Polymer Matrix Composites

Summary

The variation of the properties of polymer matrix composites (PMCs) with test temperature is most marked for matrix dominated or discontinuously reinforced systems. This Measurement Note highlights available international standards for measuring the properties at both ambient (ISO 291) and non-ambient (ISO 3205) temperatures. Use of these reference temperatures is recommended to improve the value and reliance of measured data, by enabling the data collected to be more easily compared.

Background

Typical temperatures for polymer matrix composites generally range from -55°C to 200°C , although some products may require higher and lower values (eg space applications). In general, these temperatures relate to fairly continuous or repeated exposure but occasionally only short-term or single-shot capability is needed.

It should be noted that humidity levels can also cause the properties to vary in the short term as well as in the long term. Longer term thermal and moisture effects will be reviewed in subsequent Measurement Notes.

This note was prepared, as one of a series, as a result of investigations undertaken under the DTI Design of Composite Components project on thermal properties of composite materials.

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Typical Operating Conditions

A survey of the industry identified typical temperature ranges of interest for several polymer matrix composites; these are given in Table 1.

Table 1 Typical working temperatures for relevant composites

Component	Material	Operating Temperature Range, °C	
		Min.	Max.
Mould tooling	Carbon-fibre or glass-fibre/epoxy	20	200
Process piping	Chopped strand mat glass-fibre/ epoxy	-30	140
Generator bindings	Filament wound glass-fibre/epoxy	-25	70
Aero engine structure	Glass-fibre fabric/ bismaleimide	-55	200
Cam cover	Glass-fibre/nylon	-40	120
Wing edge panel	Carbon fibre/epoxy	-56	40
Bridge components	Glass-fibre/ polyester pultrusion	-20	50
Brake pad	Particulates/phenolic	-20	400

Standards For Conditioning And Testing Temperatures

a) Ambient test conditions

Testing at ambient temperature is controlled by ISO 291 [1], which is similar to ISO 554 [2] and contains two alternative conditions. This standard is currently being revised and reached the final formal ballot stage in 1997. The most accurate and commonly used condition in test laboratories is $23 \pm 1^\circ\text{C}$, with or without humidity control at $50 \pm 5\%$ RH. Ordinary tolerances are $\pm 2^\circ\text{C}$ and $\pm 10\%$ RH. For tropical countries 27°C and 65% RH are alternatives. Humidity control would be used in most research and design data testing.

Table 2 Temperature and humidity values given in ISO 291

Symbol for standard atmosphere	Air Temperature, t (°C)	Relative Humidity, U (%)	Remarks
23/50	23	50	Normal use
27/65	27	65	Tropical climates, if agreed

Similar documents are prEN 2743 [3] and EN 62 [4]. The later standard, which is similar but not identical to ISO 291, was produced specifically to support a directive introduced in 1976 for GRP used for transport of dangerous liquids but will be replaced by the revised ISO 291 [1] standard as it is being balloted as a dual EN ISO standard. This standard will then be implemented as the BSI standard, BS EN ISO 291. There are two levels of tolerance available:

Class 1

$\pm 1^\circ\text{C}$ for temperature and $\pm 5\%$ for relative humidity;

Class 2

$\pm 2^\circ\text{C}$ for temperature and $\pm 10\%$ for relative humidity.

b) Non-ambient test temperatures

Both ISO 3025 [5] and EN (Aerospace) 2744 [6] standards exist giving recommended non-ambient test temperatures. The ISO values, listed in Table 3, are not limited in scope to any class of material and therefore exceed the requirements of PMCs, whereas the aerospace standard is restricted to non- metallics.

The ISO and EN standards give a large number of additional temperatures which are used in specific specifications. In some cases these values are close together and close to a standard ISO value (eg 37°C, 38°C and ISO value equal to 40°C) and it is recommended that the closest ISO value be used instead. Some additional values arise from conversion of degree F values.

Table 3 ISO 320 [5] reference test temperatures

Recommended Reference Temperature °C
- 269
- 196
- 161
- 70
- 55*
- 40*
- 25*
- 10
0
5
25
40
55
70*
85*
100*
105
125
150*
175
200*
225
250*
275
300*
350
400
450
500
600
700
800
900
1000

The full range is given in [Table 3](#) although this is well above constant exposure temperatures for PMCs. Asterisked values are those found to be currently used in the industry survey, together with many non- standard values.

The temperature tolerances (see [Table 4](#)) are slightly tighter for the ISO standard (cf EN 2744) between 0°C and 105°C at $\pm 2^\circ\text{C}$ compared with $\pm 3^\circ\text{C}$, otherwise the requirements are the same. Below -75°C the tolerance is equipment related and is not controlled by the specification. EN 2743 [7], which is similar to ISO 291, specifies an ordinary tolerance of $\pm 2^\circ\text{C}$ and a reduced tolerance of $\pm 1^\circ\text{C}$ for ambient testing.

Table 4 Temperature tolerances given in ISO 3205

Temperatures, °C	Tolerance, °C
$-75 \leq \theta \leq 0$	± 3
$0 \leq \theta \leq 105$	± 2
$105 \leq \theta \leq 200$	± 3
$200 \leq \theta \leq 400$	± 5
$400 \leq \theta \leq 750$	± 10
$750 \leq \theta \leq 1000$	± 15

Conclusions

The industry survey found that several of the reference temperatures were in use (see asterisked values in [Table 3](#)) as were many non-standard temperatures. For the normal temperature range, -55°C to 200°C , the steps of 15°C and 25°C should allow sufficient discrimination of the properties, unless the material is being used close to a transition (eg glass transition), which would not normally be recommended.

All customers for testwork at NPL are recommended to use the reference temperatures in 1503205, in accordance with NPL internal projects.

Use of 150 3205 temperatures will improve markedly the availability of databases on the thermal response of composite materials.

References

1. ISO 291:1977. "Plastics: Standard atmospheres for conditioning and testing" (under revision).
2. ISO 554:1976. "Standard atmospheres for conditioning and/ or testing-specification" .
3. prEN 2743. "Reinforced Plastics -Standard atmospheres for conditioning and testing". (Aerospace series).
4. EN 62:1977. "Glass reinforced plastics: Standard atmospheres for conditioning and testing".
5. ISO 3025:1994. "Preferred test temperatures".
6. EN 2744:1992. "Non-metallic materials -Preferred test temperatures". (Aerospace series).

BS, EN and ISO standards can be obtained from

BSI, Customer Services
 389 Chiswick High Road
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 Tel: 020 8996 7000
 Fax: 020 89967001

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