

Contents of CAMPUS^â

1 General Principles

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1.1 Basis of CAMPUS

The basis of CAMPUS are the following three International Standards:

ISO 10350-1, Plastics - Acquisition and presentation of comparable single-point data – Part 1: Moulding materials.

ISO 11403-1, Plastics - Acquisition and presentation of comparable multipoint data - Part 1: Mechanical properties.

ISO 11403-2, Plastics - Acquisition and presentation of comparable multipoint data - Part 2: Thermal and processing properties.

These standards were developed by the Technical Committee ISO/TC 61 “Plastics”, Sub-Committee SC 2 “Mechanical Properties”, Working Group WG 8 “Forms of Data Presentation”. CAMPUS represents an application of these standards in the sense that, as far as possible,

- the data tables in CAMPUS are taken from the above International Standards only,
- the lowest status of development for their application generally being „Draft International Standard, DIS“. This relates to the above indicated standards and to the relevant material and test standards as well.

1.2 Scope of this Document

The status of ISO 10350-1, ISO 11403-1 and ISO 11403-2 and of the many standards involved, combined with the rules of CAMPUS given above, are difficult to handle for all that are less familiar with the standardization system. The present document therefore lists the single-point and multipoint properties included in CAMPUS 5.0 and summarizes the test conditions and supplementary instructions that are given in the standards and often are asked for.

1.3 Specimen Conditioning

1.3.1 Humidity Insensitive Materials

For materials that have properties that are not significantly sensitive to any absorbed water, test specimens are conditioned according to the International Standard appropriate to the material. If the material standard is not available, condition test specimens at (23 ± 2) °C and $(50 \pm 10)\%$ r.h. for a minimum length of time of 88 h (see ISO 291, Class 2).

1.3.2 Humidity Sensitive Materials

1.3.2.1 Dry and Humid State

For those materials having properties that are significantly dependent upon the concentration of any absorbed water, consult the relevant materials standard for procedures for conditioning specimens to achieve material that has one of the following two states:

- Dry: For thermoplastics the dry state is that as molded.
- Humid: In equilibrium with an atmosphere of 50% r.h. at 23 °C.

Following such conditioning, all test specimens are stored at (23 ± 2) °C for a minimum of 16 h before testing. The storage atmosphere is either dry (sealed) or at 50% r.h. depending upon the condition of the specimen.

Ensure that humid test specimens do not markedly lose water and dry test specimens do not markedly take up water up to the end of the individual test.

The different states are handled like one material, presenting singlepoint-data in two columns and multipoint data as separate graphics . But with the following exceptions:

1.3.2.2 Exceptions for Single-Point Data

Property		Symbol	Status
Melt volume-flow rate		MVR	Dry only
Molding shrinkage for thermoplastics	parallel	S_{Mp}	
	normal	S_{Mn}	
Tensile creep modulus (at room temperature)	1h	E_{tc1}	Humid only
	1000h	$E_{tc}10^3$	
Melting temperature		T_m	Dry only
Glass transition temperature		T_g	
Flexural softening temperature		$T_f1,8$	
		$T_f0,45$	
		$T_f8,0$	
Vicat softening temperature		$T_v50/50$	
Coefficient of linear thermal expansion	parallel	a_p	
	normal	a_n	
Burning behavior	1,6 mm thick	$B50/1.6$	Humid only
		$B500/1.6$	
	-, - mm thick	$B50/-,-$	
		$B500/-,-$	
Flammability by oxygen index		$OI23$	
Surface resistivity		S_e	
Comparative tracking index		CTI	

Table 1: Exceptions for single-point data

1.3.2.3 Exceptions for Multipoint Data

Property Variable Parameter	Symbol	Status
Shear modulus (real part) Temperature	$G'(T)$	Dry only
<i>Specific enthalpy difference</i> Temperature	$DH(T)/m$	
Shear <i>stress</i> (viscosity) Shear rate Temperature	$t(\dot{\gamma}, T)$	
<i>Specific volume</i> Temperature Pressure	$v(T, p)$	

Table 2: Exceptions for multipoint data

1.3.2.4 Exceptions for Creep Data

Creep tests are carried out in a laboratory with the atmosphere 23 °C / 50 % r.h.. For testing at an elevated temperature this results in test atmospheres of the same absolute but markedly lower relative humidity, that can be calculated according to the following equation.

$$U_T = U_{23} \exp [- T^* (T_{23}^{-1} - T^{-1})] \quad (1.1)$$

where

- U_T is the relative humidity at the test temperature T , in % r.h.;
- U_{23} is the relative humidity of the laboratory atmosphere, i.e. at 23 °C, in % r.h.;
- $T_{23} = 296$ K is the temperature of the laboratory atmosphere in K;
- T is the test temperature in K;
- $T^* = 5213$ K.

E.g. starting at the laboratory atmosphere 23 °C / 50 % r.h. and raising the test temperature to $T = (60 + 273)$ K leads to a the test humidity of $U_T = 7$ % r.h. only. Ensure that for a humidity sensitive material the test specimen is in equilibrium with the relevant test atmosphere before starting the test.

Resulting from the conditions described above the humidity of the test specimens differs between different test temperatures: Creep data of humidity sensitive materials, taken at different temperatures, do not refer to comparable material states.

1.3.3 Ageing of Test Specimens

(Physical) ageing is the change of a property versus time without any chemical change (e.g. decomposition). It takes place after the processing of the test specimen, i.e. after cooling from elevated temperatures to a lower temperature, at which structural relaxation times are long in comparison with the ageing time. Ageing may be generated by volume retardation, relaxation of internal stresses and recrystallization. Its type, amount and rate depends on the ageing temperature.

In case of room-temperature testing the ageing time is the period between cooling down from processing temperatures and reading the property, the minimum of this period being the minimum conditioning time, given in clause 1.3.1 and 1.3.2, i.e. 88 h, and all properties that require testing times up to some hours maximum, conventionally are carried out soon after. Therefore the ageing time and the conditioning time generally are in the same order of magnitude, resulting in extensively comparable ageing states and thus room-temperature properties. This holds too for the testing at low temperatures, which retard further ageing.

The ageing process is more complicated when measurements are made at elevated temperatures: The room-temperature ageing of the conditioning period may at least partly be reversed, followed by a modified ageing type at the higher temperature. For testing the thermal properties melting (T_m), glass (T_g) and softening temperatures (T_f and T_v) as well as the coefficients of thermal expansion (α_p and α_n) the temperature run is fixed in the relevant testing standard. Thus the measured properties are based on states of ageing, which are comparable between different laboratories. In order to ensure this, no conditioning at elevated temperatures is provided beyond the procedures described in the relevant standard for the material. For testing stress-strain diagrams at elevated temperatures a warm-up time as short as possible is used that suffices for attaining homogeneous temperatures. e.g. 20 min to 30 min.

An insufficient state of standardization is present for the testing of creep data: The wide range of testing times between 1 h and 10^3 h or even 10^4 h is not accompanied by suitably fixed conditioning i.e. ageing times. For room-temperature testing the conditioning time of ≤ 88 h results in floating ageing states for a large range of the testing-time „window“. For the testing at elevated temperatures even no conditioning procedure is given, though the action of ageing is well described in ISO 899-1, annex A. The only reasonable definition would be: „Condition the test specimen prior to loading at the relevant test temperature, for at least the planned testing time.“ This however will double the amount of time for testing creep data.

1.4 Test Atmosphere

1.4.1 Principles

The test is conducted in the same atmosphere as used for conditioning, or the residence time between conditioning and including testing is short enough to prevent the specimens from undergoing any changes in their material state and hence behavior.

1.4.2 Change of Humidity

The testing of room-temperature properties commonly is carried out at the laboratory atmosphere of 23 °C and 50% r.h.. For testing initially dry plastics, the maximum residence time that avoids unacceptable changes of properties depends on the thickness of the test specimen and the sensitivity of the test method. Up to now the following examples are known.

The tensile modulus versus temperature of PA66 can be described by the following equation:

$$E_t(t) / E_{t0} = 1 - 0,028 t^{1/2}/h \quad (1.2)$$

where

- $E_t(t)$ is the tensile modulus after the residence time t ;
- E_{t0} is the tensile modulus of the initially dry material;
- t is the residence time in hour, h ;
- h is the specimen thickness in millimeter, mm .

At $h = 4$ mm thickness e.g., the tensile modulus decreases by 1% within two hours.

The impact strength of initially dry plastics tested at the humid laboratory atmosphere, generally increases with the residence time. For Charpy notched impact strength e.g. the maximum residence time of the test specimens is 8,2 h for PA66 and 3,2 h for PA6 to avoid an increase of more than 5%.

The action of the uncontrolled humidity uptake on the softening temperatures T_f and T_v of initially dry materials has not yet been studied.

1.4.3 Change of Temperature

Differences in temperature between the test specimen and the testing atmosphere can be handled only for short-time tests, i.e. impact tests, and often are advantageous in developing automatic equipment. ISO 179-2 (instrumented Charpy test) gives the recommendation to use resident times less than 10 s for low-temperature-conditioned specimens tested at room temperature.

1.5 Special Symbols ¹⁾

dry: Dry state of a humidity sensitive material, see clause 1.3.2.
 cond: Humid state of a humidity sensitive material, see clause 1.3.2.

- + „Applicable“ or „used“: For a not-numerical data field, e.g. for functions, manufacturing process methods and additives.
- „Missing“ or „not used“: Instead of a value for a numerical data field and for a not-numerical data field, e.g. functions, manufacturing process methods and additives.
- * „Not applicable“ or „not relevant“: Instead of a value for a numerical data field, see e.g. table 5 (tensile properties).
- > „Greater than“: The relevant property is beyond a limit provided in CAMPUS for recording, e.g. (nominal) strain to break: (ϵ_{tB}) $\epsilon_t > 50\%$, or volume and surface resistivity: $\rho_e > 10^{13} \Omega \text{ cm}$ and $\sigma_e > 10^{15} \Omega$.

N	„Non break“	}
P	„Partial break“	
H	„Hinge break“	
C	„Complete break“	

N	}	„No class satisfied“	}	Classes of burning behavior, see 2.2.3.5, properties B50 and B500.	
HB		}			See IEC 60695-11-10
V-2					
V-1					
V-0					
5VA	}	See IEC 60695-11-20			
5VB					

UL „UL- Recognized“

B	„Break point“		Designation of an ultimate point of a stress/strain diagram.
Y	„Yield point“		

↑	„Ascending order“		Marks a property, the values of which are sorted
↓	„Descending order“		

⊗	„Polar diagram“		Marks the properties selected for
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¹⁾ When defining search requirements, CAMPUS will automatically convert lower-case letters or insert missing hyphens.