



Designation: E3433 – 24

Standard Practice for Glass Transition Temperature Reference Values¹

This standard is issued under the fixed designation E3433; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 It is the purpose of this practice to provide accepted reference values for the glass transition temperature that may be used for evaluation of dynamic mechanical analysis methods, apparatus, and software.

NOTE 1—Suggested additional or alternative reference materials or values are requested and may be submitted to the E37 Staff Manager at ASTM International, West Conshohocken PA for consideration.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

[D4092 Terminology for Plastics: Dynamic Mechanical Properties](#)

[E473 Terminology Relating to Thermal Analysis and Rheology](#)

[E1142 Terminology Relating to Thermophysical Properties](#)

[E1640 Test Method for Assignment of the Glass Transition Temperature By Dynamic Mechanical Analysis](#)

[E2161 Terminology Relating to Performance Validation in Thermal Analysis and Rheology](#)

[E3142 Test Method for Thermal Lag of Thermal Analysis Apparatus](#)

3. Terminology

3.1 Definitions:

3.1.1 Specific technical terms used in this practice are defined in Terminologies [D4092](#), [E473](#), [E1142](#), and [E2161](#) including: *bias, calibration, Celsius, certified reference material, differential scanning calorimetry, dynamic mechanical analysis, dynamic mechanical measurement, extrapolated onset value, frequency, glass transition, glass transition temperature, loss modulus, peak, storage modulus, reference material, standard reference material, tan delta, tangent delta, and temperature.*

3.1.2 *accepted reference value, n*—a value that serves as an agreed upon reference for comparison and which is derived as either a theoretical or established value, based on scientific principles or an assigned value based on experimental work.

4. Summary of Practice

4.1 The glass transition, where an amorphous material changes from an amorphous solid state into a liquidy or rubbery one, takes place over a temperature range. The glass transition temperature is a temperature taken to represent that temperature range. The glass transition temperature is a function of the thermal history, test frequency, the heating rate, and position on thermal curve assigned (see Test Method [E3142](#) and [Appendix X1](#)).

4.2 In dynamic mechanical analysis, the glass transition temperature may be assigned in at least three ways—as the extrapolated onset in the sigmoidal change in storage modulus, as the peak of the loss modulus signal, or as the peak of the tangent delta signal (see Test Method [E1640](#)). Each of these temperatures are offset from each other.

4.3 Temperature calibration of dynamic mechanical analyzers may be performed using known glass transition values.

¹ This practice is under the jurisdiction of ASTM Committee [E37](#) on Thermal Measurements and is the direct responsibility of Subcommittee [E37.02](#) on Reference Materials.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

4.4 There are no known certified reference materials for glass transition temperature.

4.5 It is the purpose of this practice to provide best estimate (accepted reference value(s)) for the storage modulus onset, the loss modulus peak, and tangent δ for the glass transition of a commonly available material(s) such as polycarbonate.

5. Significance and Use

5.1 The bias or offset temperature value provided by this practice may be used to calibrate or to evaluation the performance of standard, apparatus, technique, or software.

NOTE 2—Calibration or calibration verification is recommended for all signals at least annually.

5.2 The glass transition temperature is a function of heating rate. The observed values at a heating rate different from that of the calibration need to be assessed using thermal lag (see Test Method E3142).

6. Procedure

6.1 Using a standard, apparatus, technique, or software to be evaluated, obtain an experimentally observed glass transition temperature (T_o) for a material listed in Table 1. Report this value.

6.2 Obtain a corresponding reference glass transition reference temperature (T_r) from Table 1.

6.3 Determine the bias or offset temperature (T_b) using Eq 1.

NOTE 3—For measurements other than dynamic mechanical analysis, use the value for storage modulus extrapolated onset temperature from Table 1.

7. Calculation

7.1

$$T_b = T_r - T_o \quad (1)$$

where:

T_b = temperature bias, °C,
 T_r = reference temperature, °C, and
 T_o = observed temperature, °C.

8. Report

8.1 Identification of the glass transition method being examined.

8.2 A complete description of the reference material being used for the comparison, including its source and physical dimensions.

8.3 The bias (difference) between the measured and reference value.

9. Precision and Bias

9.1 This practice does not determine within or between laboratory repeatability or reproducibility precision.

9.2 Bias is the difference between an observe value and that of an accepted reference value. This standard determines that bias for the applicable standard, apparatus, technique or software. No additional bias is applicable.

10. Keywords

10.1 calibration; dynamic mechanical analysis; glass transition

TABLE 1 Meta-Analysis of the Glass Transition Temperature Determined by Dynamic Mechanical Analysis, Obtained at 1 Hz and Extrapolated to 0 K/min Heating Rate

Material	Heating Rate, °C/min	Freq. Hz	Storage Modulus Onset Temperature, °C	Loss Modulus Peak Temperature, °C	Tangent δ Peak Temperature, °C	Ref.
Polycarbonate ^A	0.0	1.0	146.7 ± 4.1	150.5 ± 3.2	154.8 ± 3.6	^B

^A 99+% purity with molecular weight greater than 50 000 g/mol (50 kDa).

^B A research report is pending at ASTM International.