



Designation: **E967–08 (Reapproved 2014) E967 – 18**

Standard Test Method for Temperature Calibration of Differential Scanning Calorimeters and Differential Thermal Analyzers¹

This standard is issued under the fixed designation E967; 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 This test method describes the temperature calibration of differential thermal analyzers and differential scanning calorimeters over the temperature range from ~~–40 to +2500°C~~ from ~~–40°C to +2000°C~~.

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 test method is similar to ISO standard 11357–1.

1.4 *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.* Specific precautionary statements are given in Section 7.

1.5 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

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

[E1142 Terminology Relating to Thermophysical Properties](#)

2.2 *ISO Standards:*³

[11357–1 Plastics-Differential Scanning Calorimetry \(DSC\)-Part 1: General Principles](#)

3. Terminology

3.1 *Definitions*—Specific technical terms used in this test method are defined in Terminologies [E473](#) and [E1142](#).

4. Summary of Test Method

4.1 This test method consists of heating the calibration materials at a controlled rate in a controlled atmosphere through a region of known thermal transition. The heat flow into the calibration material or the difference of temperature between the calibration material and a reference sample ~~and a reference material~~ is monitored and continuously recorded. A transition is marked by the absorption of energy by the specimen resulting in a corresponding endothermic peak in the heating curve.

NOTE 1—Heat flow calibrations are sometimes determined in conjunction with temperature calibration. Some differential scanning calorimeters permit both heat flow and temperature calibrations to be obtained from the same experimental procedure.

5. Significance and Use

5.1 Differential scanning calorimeters and differential thermal analyzers are used to determine the transition temperatures of materials. For this information to be meaningful in an absolute sense, temperature calibration of the apparatus ~~or~~ and comparison of the resulting data to that of known standard materials is required.

¹ This test method is under the jurisdiction of ASTM Committee [E37](#) on Thermal Measurements and is the direct responsibility of Subcommittee [E37.01](#) on Calorimetry and Mass Loss.

Current edition approved ~~March 15, 2014~~ March 15, 2018. Published ~~April 2014~~ March 2018. Originally approved in 1983. Last previous edition approved in ~~2008~~ 2014 as ~~E967–08~~ E967 – 08 (2014). DOI: ~~10.1520/E0967-08R14~~ 10.1520/E0967-18.

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

³ Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, <http://www.iso.org>.

5.2 This test method is useful in calibrating the temperature axis of differential scanning calorimeters and differential thermal analyzers.

6. Apparatus

6.1 Apparatus shall be of either type listed below:

6.1.1 *Differential Scanning Calorimeter (DSC)*, capable of heating a test specimen and a reference material at a controlled rate and of automatically recording the differential heat flow between the sample and the reference material to the required sensitivity and precision.

6.1.1.1 *A Furnace(s)*, to provide uniform controlled heating or cooling of a specimen and reference to a constant temperature or at a constant rate within the applicable temperature range of this test method.

6.1.1.2 *A Temperature Sensor*, to provide an indication of the specimen temperature.

6.1.1.3 *Differential sensors, Sensors*, to detect a heat flow (power) difference between the specimen and reference.

6.1.1.4 *Test Chamber Environment*, a means of sustaining a test chamber environment of nitrogen or other inert purge gas at a purge rate of 10 to 50 mL/min.

6.1.1.5 *A Temperature Controller*, capable of executing a specific temperature program by operating the furnace(s) between selected temperature limits at a rate of temperature change of ~~10K/min~~ $10^{\circ}\text{C}/\text{min}$.

6.1.1.6 *Data Collection Device*, to provide a means of acquiring, storing, and displaying measured or calculated signals, or both. The minimum output signals required for DSC are heat flow, temperature, and time.

6.1.2 *Differential Thermal Analyzer (DTA)*, capable of heating a test specimen and reference material at a controlled rate and of automatically recording the differential temperature between sample and reference material both to the required sensitivity and precision.

6.2 *Containers (pans, crucibles, vials, lids, closures, seals, etc.)*, that are inert to the specimen and reference materials and that are of suitable structural shape and integrity to contain the specimen and reference in accordance with the specific requirements of this test method.

6.3 *Nitrogen*, or other inert purge gas supply.

6.4 *A Balance*, to weigh specimens or containers (pans, crucibles, vials, etc.), or both to ± 0.1 mg. The balance should have a capacity greater than 20 mg.

7. Precautions

7.1 Toxic or corrosive effluents, or both, may be released when heating some material and could be harmful to personnel and to apparatus.

7.2 This test method assumes linear temperature indication. Care must be taken in the application of this test method to ensure that calibration points are taken sufficiently close together so that linear temperature indication may be approximated. Linear temperature indications means that there exists a linear, or first order, dependence on the temperature determined by the instrument's temperature sensor on the true temperature of the sample material in its container and that this relation is adequately expressed by Eq 1.

8. Calibration Materials

8.1 For the temperature range covered by many applications, the melting transition of ~~>99.99%~~ >99.99 % pure materials in Table 1 may be used for calibration.

9. Procedure

9.1 *Two Point Calibration:*

9.1.1 Select two calibration materials from Table 1, with melting temperatures one above and one below the temperature range of interest. The calibration materials should be as close to the temperature range of interest as practical.

9.1.2 Determine the apparent transition temperature for each calibration material.

9.1.2.1 Into a clean specimen holder, place a ~~5 mg to 15 mg~~ 5 mg to 15 mg weighed amount of calibration material. Other specimen masses may be used but must be indicated in the report.

9.1.2.2 Load the specimen into the instrument chamber, purge the chamber with dry nitrogen (or other inert gas) at a flow rate of 10 to 50 ~~mL/min~~ $^2/\text{min}$ throughout the experiment.

9.1.2.3 Heat (or cool) the calibration material rapidly to 30°C below the calibration temperature and allow to stabilize.

9.1.2.4 Heat the calibration material at $10^{\circ}\text{C}/\text{min}$ through the transition until baseline is reestablished above the transition. Other heating rates may be used but must be noted in the report. Record the resulting thermal curve.

NOTE 2—Temperature scale calibration may be affected by temperature scan rate, specimen holder, purge gas and purge gas flow rate. The temperature calibration shall be made under the same conditions used for test specimens.

9.1.2.5 From the resultant curve, measure the temperatures for the desired points on the curve, T_c , T_p (see Fig. 1) retaining all available decimal places.

TABLE 1 Melting Temperature of Calibration Material

NOTE 1—The values in Table 1 were determined under special, highly accurate steady state conditions that are not attainable or applicable to thermal analysis techniques. The actual precision of this test method is given in Section 12 of this test method.

Calibration Material	Melting Temperature ^A	
	(°C)	(K)
Mercury	-38.834	234.316
Water	0.01 ^B	273.16 ^B
Water	0.01 ^B	273.16
Cyclohexane	6.71 ^C	279.86
Phenoxybenzene	26.87	300.02
Gallium	29.765 ^B	302.915 ^B
Gallium	29.765 ^B	302.915
Benzoic Acid	122.37	395.52
Indium	156.598 ^B	429.748 ^B
Indium	156.5985 ^D	429.7485
Tin ^C	231.928 ^B	505.078 ^B
Tin ^E	231.928 ^{B,D}	505.078
Bismuth	271.442	544.592
Bismuth	271.402 ^D	544.552
Cadmium	321.069 ^D	594.219
Lead	327.502	600.652
Lead	327.462 ^D	600.612
Zinc	419.527 ^B	692.677 ^B
Zinc	419.527 ^{B,D}	692.677
Antimony	630.74	903.89
Antimony	630.628 ^D	903.778
Aluminum	660.32 ^B	933.47 ^B
Aluminum	660.323 ^D	933.473
Silver	961.78 ^B	1234.93 ^B
Silver	961.78 ^{B,D}	1234.93
Gold	1064.18 ^B	1337.33 ^B
Gold	1064.18 ^{B,D}	1337.33
Copper	1084.62 ^B	1357.77 ^B
Copper	1084.62 ^B	1357.77
Nickel	1455 ^D	1728
Cobalt	1494 ^D	1767
Palladium	1554 ^D	1827
Platinum	1772	2045
Rhodium	1963	2236

^A Rossini, F. D., *Pure Applied Chemistry*, Vol 22, 1970, p. 557.

^B The melting temperatures of these materials have been selected as primary fixed points for the International Practical Temperature Scale of 1990. See Mangum, B. W., and Furukawa, G. T., *Guidelines for Realizing the International Practical Temperature Scale of 1990 (ITS-90)*, NIST Technical Note 1265.

^C Shimizu, Y., Ohte, Y., and Kato, K., "Certified Reference Material NMIJ CRM 5401-a," *Thermochimica Acta*, Vol 568, 2013, pp. 61–66.

^D Updated melting temperatures were taken from Boettinger, W. J., Kattner, U. R., Moon, K.-W., and Perepezko, J.H., *DTA and Heat-flux DSC Measurements of Alloy Melting and Freezing*, NIST Special Publication 960-15, November 2006.

^E Some materials have different crystalline forms (for example, tin) or may react with the container. These calibration materials should be discarded after their initial melt.

where:

T_e = extrapolated onset temperature for fusion, °C, and

T_p = melting peak temperature, °C.

NOTE 3—The actual temperature displayed on the temperature axis differs depending upon the instrument type; for example, sample temperature, program temperature, sample program temperature average. Follow the instructions of the particular instrument manufacturer to obtain sample temperature at the point of interest.

NOTE 4—The available precision of the temperature measurements depends upon instrument capabilities and the temperature range of the test. Below 300°C, measurements to ±0.5°C are common while at greater than 700°C ± 2°C is reasonable.

NOTE 5—For high-purity crystalline materials (not polymers), T_e is taken as the transition temperature when measured by differential scanning calorimeters and other instruments where the test specimen is not in intimate contact with the temperature sensor. For instruments in which the temperature sensor is in intimate contact with the sample, (such as some differential thermal analyzers), T_p is taken as the transition temperature.

9.1.3 Using the apparent transition temperatures thus obtained, calculate the slope (S) and intercept (I) of the calibration Eq 1 (see Section 10). The slope and intercept values reported should be mean values from duplicate determinations based on separate specimens.