ASTM INTERNATIONAL

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Standard Practice for
Calculating Thermal Endurance of Materials from Thermogravimetric Decomposition Data[1]

This standard is issued under the fixed designation E1877; 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 practice covers additional treatment of the Arrhenius activation energy data determined by Test Method E1641to develop a thermal endurance curve and derive a relative thermal index for materials.

1.2 This practice is generally applicable to materials with a well-defined decomposition profile, namely a smooth, continuous mass change with a single maximum rate.

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

1.4 There is no ISO standard equivalent to this practice.

1.5 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E1641 Test Method for Decomposition Kinetics by Thermogravimetry

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *failure, n*—change in some chemical, physical, mechanical, electrical or other property of sufficient magnitude to make it unsuitable for a particular use.

3.1.2 *failure temperature (T_f), n*—the temperature at which a material fails after a selected time.

3.1.3 *relative thermal index (RTI), n*—a measure of the thermal endurance of a material when compared with that of a control with proven thermal endurance characteristics.

3.1.3.1 *Discussion*—The RTI is also considered to be the maximum temperature below which the material resists changes in its properties over a defined period of time. In the absence of comparison data for a control material, a time-to-failure of 60 000 h has been arbitrarily selected for measuring RTI. The RTI is therefore the failure temperature, T_f, obtained from the thermal endurance curve.

4. Summary of Practice

4.1 The Arrhenius activation energy obtained from Test Method E1641is used to construct the thermal endurance curve of a material from which an estimate of lifetime at certain temperatures may be obtained.

5. Significance and Use

5.1 Thermogravimetry provides a rapid method for the determination of the temperature-decomposition profile of a material.

5.2 This practice is useful for quality control, specification acceptance, and research.

5.3 This practice shall not be used for product lifetime predications unless a correlation between test results and actual lifetime has been demonstrated. In many cases, multiple mechanisms occur during the decomposition of a material, with one mechanism dominating over one temperature range, and a different mechanism dominating in a different temperature range. Users of this practice are cautioned to demonstrate for their system that any temperature extrapolations are technically sound.

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[1] This practice is under the jurisdiction of Committee E37 on Thermal Measurements and is the direct responsibility of Subcommittee E37.10 on Fundamental, Statistical and Mechanical Properties.

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[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.

6. Calculation

6.1 The following values obtained by Test Method E1641 are used to calculate thermal endurance, estimated thermal life and failure temperature.

6.1.1 The following definitions apply to 6.1 and 6.3:

6.1.1.1 E = Arrhenius activation energy (J/mol),

6.1.1.2 R = Universal gas constant (= 8.314 510 J/(mol K)),

6.1.1.3 β = Heating rate (K/min),

6.1.1.4 β' = Heating rate nearest the mid-point of the experimental heating rates (K/min),

6.1.1.5 a = Approximation integral taken from Table 1,

6.1.1.6 α = Constant conversion value,

6.1.1.7 t_f = ~~Estimated thermal life for a given value of α (min),~~ = Estimated thermal life for a given value of conversion (α) (min) (see Test Method E1641),

6.1.1.8 T_c = Temperature for the point of constant conversion for β (K), and

6.1.1.9 T_f = ~~Failure Temperature for a give value of α (K).~~ = Failure Temperature for a give value of conversion (α) (K) (see Test Method E1641).

TABLE 1 Numerical Integration Constants

E/RT	a
8	5.3699
9	5.8980
10	6.4157
11	6.9276
12	7.4327
13	7.9323
14	8.4273
15	8.9182
16	9.4056
17	9.8900
18	10.3716
19	10.8507
20	11.3277
21	11.8026
22	12.2757
23	12.7471
24	13.2170
25	13.6855
26	14.1527
27	14.6187
28	15.0836
29	15.5474
30	16.0103
31	16.4722
32	16.9333
33	17.3936
34	17.8532
35	18.3120
36	18.7701
37	19.2276
38	19.6845
39	20.1408
40	20.5966
41	21.0519
42	21.5066
43	21.9609
44	22.4148
45	22.8682
46	23.3212
47	23.7738
48	24.2260
49	24.6779
50	25.1294
51	25.5806
52	26.0314
53	26.4820
54	26.9323
55	27.3823
56	27.8319
57	28.2814
58	28.7305
59	29.1794
60	29.6281