



Designation: D2766 – 95 (Reapproved 2005)

Standard Test Method for Specific Heat of Liquids and Solids¹

This standard is issued under the fixed designation D2766; 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.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the determination of the heat capacity of liquids and solids. It is applicable to liquids and solids that are chemically compatible with stainless steel, that have a vapor pressure less than 13.3 kPa (100 torr), and that do not undergo phase transformation throughout the range of test temperatures. The specific heat of materials with higher vapor pressures can be determined if their vapor pressures are known throughout the range of test temperatures.

1.2 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

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

2. Referenced Documents

2.1 *ASTM Standards:*²

D1217 Test Method for Density and Relative Density (Specific Gravity) of Liquids by Bingham Pycnometer

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *specific heat*—the ratio of the amount of heat needed to raise the temperature of a mass of the substance by a specified amount to that required to raise the temperature of an equal mass of water by the same amount, assuming no phase change in either case.

3.2 *Symbols:*

¹ This test method is under jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.11 on Engineering Sciences of High Performance Fluids and Solids.

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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.

T_f	= temperature of hot zone, °C,
T_c	= initial temperature of calorimeter, °C,
T'	= $T_f - T_c$ = temperature differential, °C,
R_1	= resistance of nominal 1- Ω standard resistor,
R_{100}	= resistance of nominal 100- Ω standard resistor,
$R_{10\ 000}$	= resistance of nominal 10 000- Ω standard resistor,
E_1	= emf across nominal 1- Ω standard resistor,
E_{100}	= emf across nominal 100- Ω standard resistor,
$E_{10\ 000}$	= emf across nominal 10 000- Ω standard resistor,
t_c	= time of application of calibration heater current, s,
q	= total heat developed by calibration heater, cal,
ΔE_c	= total heat effect for container, mV,
ΔE_s	= total heat effect for sample + container, mV,
Δe_c	= total heat effect for calibration of calorimeter system during container run, mV,
Δe_s	= total heat effect for calibration of calorimeter system during sample run, mV,
ΔH_c	= total enthalpy change for container changing from T_f to T_c ,
ΔH_T	= total enthalpy change for sample plus container changing from T_f to T_c ,
ΔH_s	= total enthalpy change for sample changing from T_f to T_c ,
F	= calorimeter factor,
W	= weight of sample corrected for air buoyancy
d_f	= density of sample at T_f ,
d_c	= density of sample at T_c ,
V_T	= total volume of sample container,
V_f	= volume of sample vapor at T_f ,
V_c	= volume of sample vapor at T_c ,
P_f	= vapor pressure of sample at T_f ,
P_c	= vapor pressure of sample at T_c ,
N_f	= moles sample vapor at T_f ,
N_c	= moles sample vapor at T_c ,
N	= moles sample vapor condensed,
ΔH_v	= heat of vaporization of sample,
R	= gas constant, and
K	= heat of vaporization correction.

3.3 Units:

3.3.1 The energy and thermal (heat) capacity units used in this method are defined as follows:

- 1 cal (International Table) = 4.1868 J
- 1 Btu (British thermal unit, International Table) = 1055.06 J
- 1 Btu/lb °F = 1 cal/g °C
- 1 Btu/lb °F = 4.1868 J/g K

3.3.2 For all but the most precise measurements made with this method the rounded-off value of 4.19 J/cal can be used as this is adequate for the precision of the test and avoids the difficulty caused by the dual definition of the calorie.

4. Summary of Test Method

4.1 The enthalpy change, ΔH_c , that occurs when an empty sample container is transferred from a hot zone of constant temperature to an adiabatic calorimeter at a fixed initial temperature is measured for selected hot zone temperatures evenly spread over the temperature range of interest.

4.2 The enthalpy change, ΔH_T , that occurs when a container filled with the test specimen is transferred from a hot zone of constant temperature, T_c , to an adiabatic calorimeter at a fixed initial temperature is measured for selected hot-zone temperatures evenly spread over the temperature range of interest.

4.3 The net enthalpy change per gram of sample is then expressed as an analytical power function of the temperature differential T' . The first derivative of this function with respect to the actual temperature, T_p , yields the specific heat of the sample as a function of temperature. Actual values of the specific heat may be obtained from solutions of this equation which is valid over the same range of temperatures over which the total enthalpy changes, ΔH_T , were measured.

5. Significance and Use

5.1 The specific heat or heat capacity of a substance is a thermodynamic property that is a measure of the amount of energy required to produce a given temperature change within a unit quantity of that substance. It is used in engineering calculations that relate to the manner in which a given system may react to thermal stresses.

6. Apparatus

6.1 *Drop-Method-of-Mixtures Calorimeter*, consisting essentially of a vertically mounted, thermostatically controlled, tube furnace and a water-filled adiabatic calorimeter. The furnace is mounted with respect to the calorimeter in such a way that it may be swung from a remote position to a location directly over the calorimeter and returned rapidly to the remote position. The sample container may thus be dropped directly into the calorimeter with a minimum transfer of radiation from furnace to calorimeter. Details of construction are shown in Fig. 1.

6.2 *Sample Container*—A stainless steel sample container with a polytetrafluoroethylene seal suitable for use at temperatures up to 533 K (500°F) is shown in Fig. 2.

6.3 *Potential Measuring Devices* (two required), potential measuring device capable of measurement of up to 1 V with a precision of 10^{-6} V or a potentiometer assembly with sensitivity of at least 1 μ V or a digital multimeter with equivalent

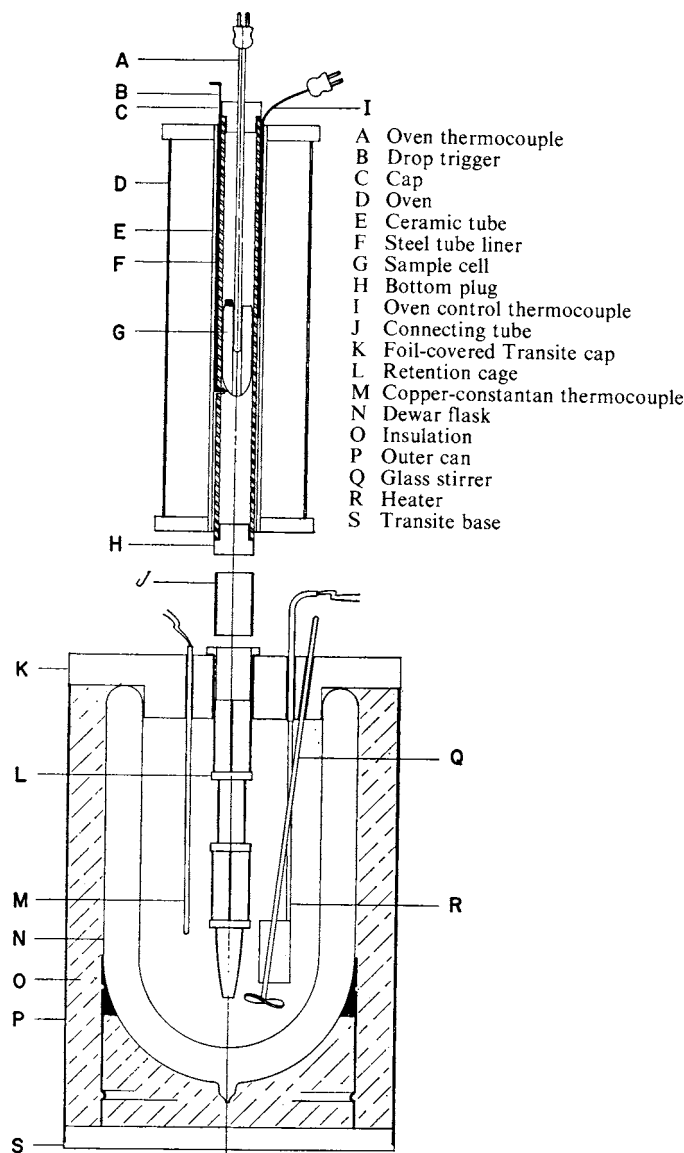


FIG. 1 Specific Heat Apparatus

sensitivity, range, and a minimum of six digit resolution is acceptable. A direct reading digital temperature indicating device may be substituted for the potential measuring device for the purpose of measuring the temperature of the capsule while in the tube furnace. See Fig. 3.

6.4 *Resistor*, 1- Ω precision type.^{3,4}

6.5 *Resistor*, 100- Ω precision type.^{3,4}

6.6 *Resistor*, 10 000- Ω precision type.^{3,4}

6.7 *Amplifier*, zero centered range, linear response with preset ranges to include ± 25 μ V, ± 100 μ V, ± 200 μ V, ± 500 μ V, ± 1000 μ V, and ± 2000 μ V; with error not to exceed ± 0.04 % of output; with zero drift after warm-up not to exceed

³ If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend.

⁴ The sole source of supply of the apparatus known to the committee at this time is Models 9330/1, 9330/100, 9330/10K, Guildline Instruments, Inc., 103 Commerce St., Ste 160, Lake Mary, FL 32795-2590.