Designation: D 6549 – 00

An American National Standard

Standard Test Method for Determination of Cooling Characteristics of Quenchants by Cooling Curve Analysis with Agitation (Drayton Unit)[1]

This standard is issued under the fixed designation D 6549; 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 covers the equipment and the procedure for evaluation of quenching characteristics of a quenching fluid by cooling rate determination.

1.2 This test method is designed to evaluate quenching fluids with agitation, using the Drayton Agitation Unit.

1.3 The values in SI units are to be regarded as the standard. The values in parentheses are for information only.

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

2. Referenced Documents

2.1 *ASTM Standards:*

E 220 Test Method for Calibration of Thermocouples by Comparison Techniques[2]

E 230 Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples[2]

2.2 *SAE Standards:*[3]

AMS 5665 Nickel Alloy Corrosion and Heat Resistant Bars, Forgings and Rings

2.3 *Other Standards:*[4]

Wolfson Engineering Group Specification Laboratory Tests for Assessing the Cooling Curve Characteristics of Industrial Quenching Media

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *aqueous polymer quenchant*—an aqueous polymer quenchant is an aqueous solution containing a water soluble polymer, typically including poly(alkylene glycol), poly(ethyl oxazoline), poly(sodium acrylate), and poly(vinyl pyrrolidone) **(1,2,3)**.[5] The quenchant solution also typically contains additives for corrosion and foam control, if needed. Quench severity of aqueous polymer quenchants is dependent on concentration and molecular weight of the specific polymer being evaluated, quenchant temperature, and agitation rate as shown in Fig. 1, Fig. 2, and Fig. 3 respectively.

3.1.2 *cooling curve*—the cooling curve is a graphical representation of the cooling time (t) versus temperature (T) response of the probe (see 7.3). An example is illustrated in Fig. 4.

3.1.3 *cooling curve analysis*—the process of quantifying the cooling characteristics of a quenchant based on the temperature versus time profile obtained by cooling a preheated metal probe assembly (see Fig. 4) under standard conditions **(1-7)**.

3.1.4 *cooling rate curve*—the cooling rate curve is a graphical representation of first derivative of the cooling curve, the rate of temperature change (dT/dt) versus temperature. An example is illustrated in Fig. 4.

3.1.5 *quenchant*—a quenching medium may be either a liquid or a gas. Gasses that are used as quenchants include air, nitrogen, argon, and hydrogen and, with the exception of air, which is used at atmospheric pressure, are used under pressure. Liquid quenchants include water, brine (most commonly dilute aqueous solutions of sodium chloride or sodium hydroxide), oil, molten salt, molten metal, and aqueous solutions of water soluble polymers. Water, brine, oil, and aqueous polymer quenchants are generally used with agitation.

3.1.6 *quench severity*—the ability of a quenching medium to extract heat from a hot metal **(8)**.

4. Summary of Test Method

4.1 This test method determines the cooling time versus temperature of a standard nickel alloy probe assembly after it has been heated in a furnace to 850°C (1562°F) and then quenched in an aqueous polymer quenchant solution. The temperature inside the probe assembly and the cooling times are recorded at selected time intervals to establish a cooling temperature versus time curve. The resulting cooling curve (profile) may be used to evaluate quench severity (see Note 1).

NOTE 1—Where appropriate for production testing, a furnace temperature from 815 to 857°C (1500 to 1575°F) may be used.

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.L0.06 on Nonlubricating Process Fluids.

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[2] *Annual Book of ASTM Standards*, Vol 14.03.

[3] Available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

[4] Available from Wolfson Heat Treatment Centre, Aston University, Aston Triangle, Birmingham B4 7ET, England.

[5] The boldface numbers in parentheses refer to the list of references at the end of this standard.

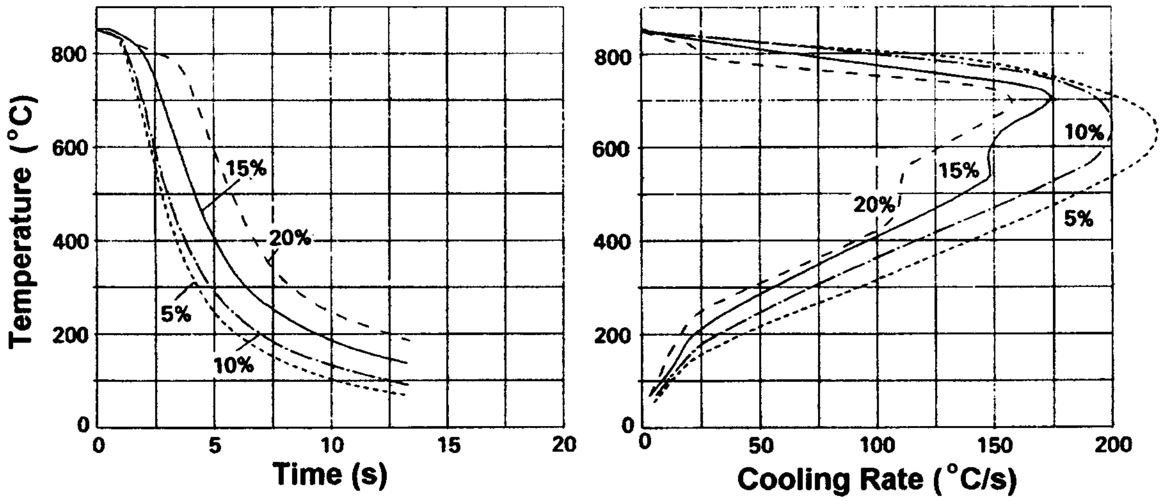

FIG. 1 Effect of Quenchant Concentration on Cooling Curve Performance for a Poly(Alkylene Glycol) Quenchant at 30°C and 0.5 m/s

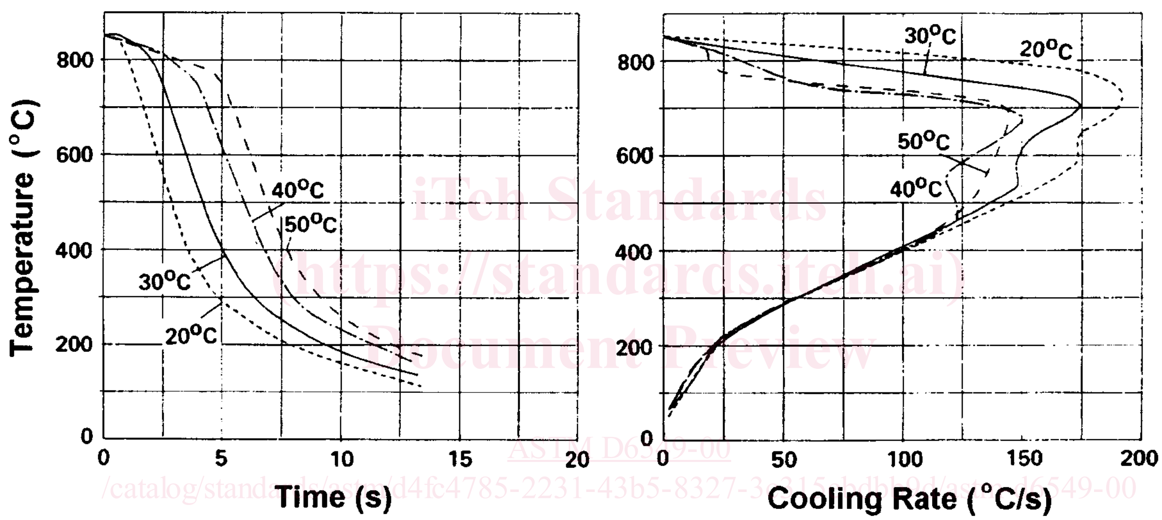

FIG. 2 Effect of Bath Temperature Variation on Cooling Curve Performance for 15 % Aqueous Solution of Poly (Alkylene Glycol) Quenchant at 0.5 m/s

5. Significance and Use

5.1 This test method provides a cooling time versus temperature curve (profile) that can be related to physical properties, such as the hardness obtainable upon quenching of a metal. The results obtained by this test method may be used as a guide in quenchant selection or as a comparison of quench severities of different quenchants, new or used.

6. Interferences

6.1 The presence of contaminants, such as oil, salt, metalworking fluids, forging lubricants, and polymer degradation, may affect cooling curve results obtained by this test method for aqueous polymer quenchants.

7. Apparatus

7.1 *Furnace*—Use a horizontal or vertical electrical resistance tube-type furnace capable of maintaining a constant minimum temperature of 850°C (1562°F) over a heated length of not less than 120 mm (4.72 in.) and a probe positioned in the center of the heating chamber. The furnace shall be capable of maintaining the probe's temperature within ±2.5°C (4.5°F) over the specimen length. The furnace, that is, the radiant tube heating media, shall be used with ambient atmosphere.

7.2 *Measurement System*—The temperature-time measurement system shall be a computer based data acquisition system capable of providing a permanent record of the cooling characteristics of each sample tested, producing a record of variation in the test probe assembly of temperature with respect to time and cooling rate with respect to temperature.

7.3 *Probe*—The probe shall be cylindrical, having a diameter of 12.5 ± 0.01 mm (0.492 ± 0.0004 in.) and a length of 60 ± 0.25 mm (2.362 ± 0.01 in.) with a 1.45 to 1.65-mm (0.057 to 0.065-in.) sheathed Type K thermocouple in its geometric center. The probe shall be made of a nickel Alloy 600 (UNS N06600), purchased in accordance with AMS 5665, which has a nominal composition of 76.0 % Ni, 15.5 % Cr, 8.0 % Fe, 0.08 % C, and 0.25 % maximum Cu. The probe shall be attached to a support tube with a minimum length of 200 mm (7.874 in.). The thermocouple sheathing and the support tube shall be the same material as the probe (see Note 2). See