



# Standard Test Method for Determination of Cooling Characteristics of Aqueous Polymer Quenchants by Cooling Curve Analysis with Agitation (Tensi Method)<sup>1</sup>

This standard is issued under the fixed designation D 6482; 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 ( $\epsilon$ ) 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 Tensi agitation apparatus.

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:

D 6200 Test Method for Determination of Cooling Characteristics of Quench Oils by Cooling Curve Analysis<sup>2</sup>

E 220 Test Method for Calibration of Thermocouples by Comparison Techniques<sup>3</sup>

E 230 Specification and Temperature-Electromotive Force (EMF) Tables for Standardized Thermocouples<sup>3</sup>

### 2.2 SAE Standard:<sup>4</sup>

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

### 2.3 Japanese Industrial Standards:<sup>5</sup>

JIS K 2242 Heat Treating Oil

JIS K 6753 Di-2-ethylhexyl Phthalate

### 2.4 Wolfson Engineering Group:<sup>6</sup>

Laboratory Tests for Assessing the Cooling Curve of Indus-

trial Quenching Media

## 3. Terminology

### 3.1 Definitions of Terms Specific to This Standard:

3.1.1 *aqueous polymer quenchant*—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**).<sup>7</sup> 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 Figs. 1-3 respectively.

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

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. 5) under standard conditions (**1,3,4**).

3.1.4 *cooling rate curve*—obtained by calculating the first derivative ( $dT/dt$ ) of the cooling time-temperature curve. An example is illustrated in Fig. 4b.

3.1.5 *quenchant*—any medium, liquid or gas that may be used to mediate heat transfer during the cooling of hot metal.

3.1.6 *quench severity*—the ability of a quenching medium to extract heat from a hot metal (**5**).

## 4. Summary of Test Method

4.1 The nickel alloy probe assembly's cooling time versus temperature is determined after placing the assembly in a furnace and heating to 850°C (1562°F) and then quenching into 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 may be used to evaluate quench severity (see Note 1).

NOTE 1—For production testing, the furnace temperature of 815 to

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 05.04.

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 14.03.

<sup>4</sup> Available from Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.

<sup>5</sup> Available from Japanese Standards Association, 1-24, Akasaka 4, Minato-ku, Tokyo 107 Japan.

<sup>6</sup> Wolfson Engineering Group Specification, available from Wolfson Heat Treatment Centre, Aston University, Aston Triangle, Birmingham B4 7ET, England, 1980.

<sup>7</sup> The boldface numbers in parentheses refer to the list of references at the end of this standard.