Designation: D6666 − 04 (Reapproved 2014)

Standard Guide for Evaluation of Aqueous Polymer Quenchants[1]

This standard is issued under the fixed designation D6666; 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 guide provides information, without specific limits, for selecting standard test methods for testing aqueous polymer quenchants for initial qualification, determining quality, and the effect of aging.

1.2 *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 requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D95 Test Method for Water in Petroleum Products and Bituminous Materials by Distillation
D445 Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
D892 Test Method for Foaming Characteristics of Lubricating Oils
D1744 Test Method for Determination of Water in Liquid Petroleum Products by Karl Fischer Reagent
D1747 Test Method for Refractive Index of Viscous Materials
D1796 Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure)
D2624 Test Methods for Electrical Conductivity of Aviation and Distillate Fuels
D3519 Test Method for Foam in Aqueous Media (Blender Test) (Withdrawn 2013)[3]
D3601 Test Method for Foam In Aqueous Media (Bottle Test) (Withdrawn 2013)[3]
D3867 Test Methods for Nitrite-Nitrate in Water
D4327 Test Method for Anions in Water by Suppressed Ion Chromatography
D5296 Test Method for Molecular Weight Averages and Molecular Weight Distribution of Polystyrene by High Performance Size-Exclusion Chromatography
D6482 Test Method for Determination of Cooling Characteristics of Aqueous Polymer Quenchants by Cooling Curve Analysis with Agitation (Tensi Method)
D6549 Test Method for Determination of Cooling Characteristics of Quenchants by Cooling Curve Analysis with Agitation (Drayton Unit)
E70 Test Method for pH of Aqueous Solutions With the Glass Electrode
E979 Practice for Evaluation of Antimicrobial Agents as Preservatives for Invert Emulsion and Other Water Containing Hydraulic Fluids
E2275 Practice for Evaluating Water-Miscible Metalworking Fluid Bioresistance and Antimicrobial Pesticide Performance

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *austenite, n*—solid solution of one or more elements in face-centered cubic iron (gamma iron) and unless otherwise designated, the solute is generally assumed to be carbon (**1**).[4]

3.1.2 *austenitizing, n*—forming austenite by heating a ferrous alloy into the transformation range (partial austenitizing) or above the transformation range (complete austenitizing). When used without qualification, the term implies complete austenitizing (**1**).

3.1.3 *aqueous polymer quenchant, n*—a solution containing water, and one or more water-soluble polymers including poly(alkylene glycol), poly(vinyl pyrrolidone), poly(sodium acrylate), and poly(ethyl oxazoline) (**2, 3**) and additives for corrosion and foam control, if needed.

3.1.4 *biodegradation, n*—the process by which a substrate is converted by biological, usually microbiological, agents into simple, environmentally acceptable derivatives. (**4**)

[1] This guide is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.L0.06 on Non-Lubricating Process Fluids.

Current edition approved May 1, 2014. Published July 2014. Originally approved in 2001. Last previous edition approved in 2009 as D6666 – 04 (2009). DOI: 10.1520/D6666-04R14.

[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] The last approved version of this historical standard is referenced on www.astm.org.

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

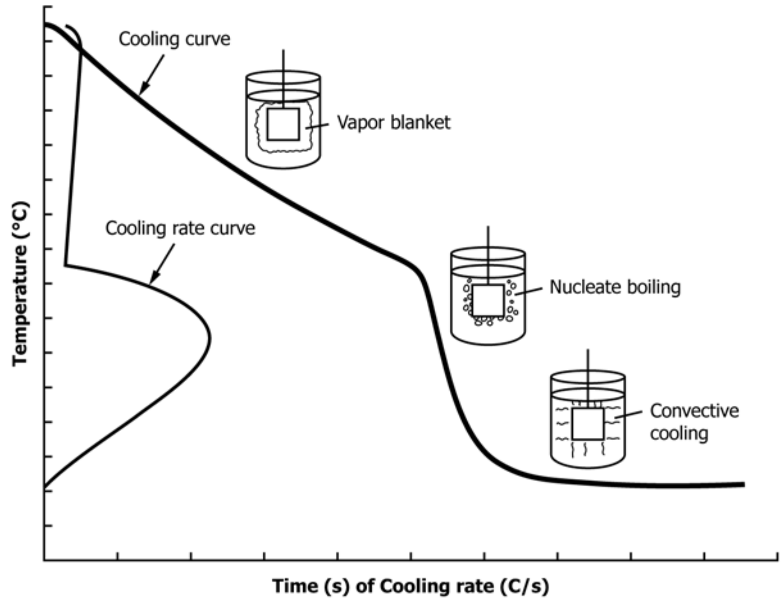


FIG. 1 Cooling Mechanisms of the Quenching Process

3.1.5 *biodeterioration, n*—loss of product quality and performance and could be regarded as the initial stages of biodegradation (see 3.1.4) , but in the wrong place at the wrong time, that is when the product is stored or in use. (**4**)

3.1.6 *convective cooling, n*—after continued cooling, and the interfacial temperature between the cooling metal and the aqueous polymer quenchant is less than the boiling point of the water in the quenchant solution at which point cooling occurs by a convective cooling process. For convective cooling, fluid motion is due to density differences and the action of gravity and includes both natural motion and forced circulation (**1, 5**). This process is illustrated in Fig. 1.

3.1.7 *cooling curve, n*—a graphical representation of the cooling time (*t*)—temperature (*T*) response of the probe such as that shown in Fig. 1. (**5**)

3.1.8 *cooling curve analysis, n*—the process of quantifying the cooling characteristics of a quenchant medium based on the temperature versus time profile obtained by cooling a preheated metal probe assembly (see Fig. 2) under specified conditions which include: probe alloy and dimensions, probe and bath temperature, agitation rate, and aqueous polymer quenchant concentration.

3.1.9 *cooling rate curve, n*—obtained by calculating the first derivative (*dT/dt*) of the cooling time-temperature curve as illustrated in Fig. 1. (**5**)

3.1.10 *dragout, n*—solution carried out of a bath on the metal being quenched and associated handling equipment. (**1**)

3.1.11 *full-film boiling, n*—upon initial immersion of hot steel into a quenchant solution, a vapor blanket surrounds the metal surface resulting in full-film boiling as shown in Fig. 1. (**5**)

3.1.12 *nucleate boiling, n*—when the vapor blanket surrounding the hot metal collapses and a nucleate boiling process occurs as illustrated in Fig. 1. (**5**)

3.1.13 *quenchant medium, n*—any liquid or gas, or mixture, used to control the cooling of a metal to facilitate the formation of the desired microstructure and properties. (**1**)

3.1.14 *quench severity, n*—the ability of a quenchant medium to extract heat from hot metal. (**6**)

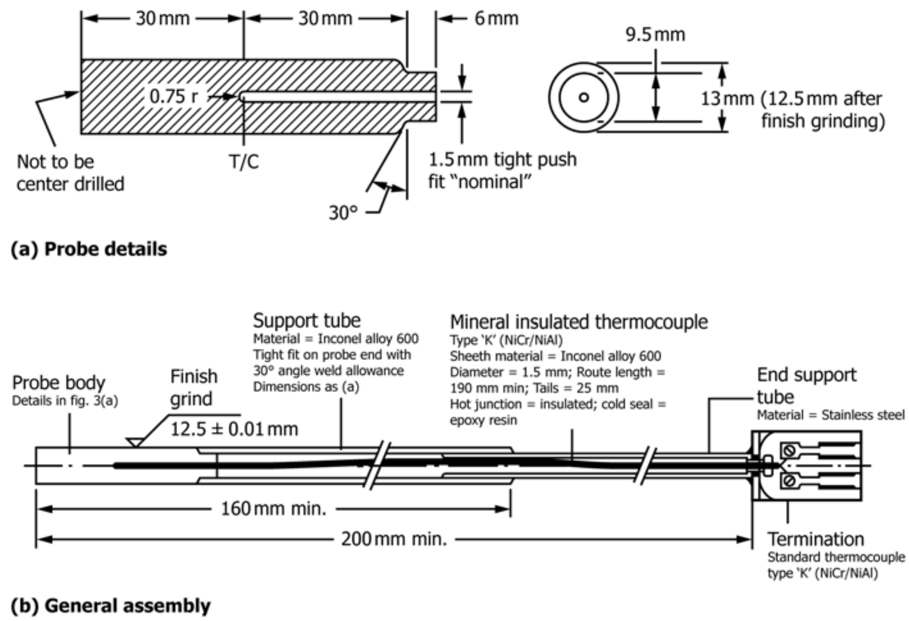
3.1.15 *transformation temperatures, n*—characteristic temperatures that are important in the formation of martensitic microstructure of steel including: A_{e1}—equilibrium austenitization phase change temperature; M_S—temperature at which transformation of austenite to martensite starts during cooling and M_f—temperature at which transformation of austenite to martensite is completed during cooling. (**1**)

4. Significance and Use

4.1 The significance and use of each test method will depend on the system in use and the purpose of the test method listed under Section 7. Use the most recent editions of the test methods.

5. Quenching Process

5.1 *Aqueous Polymer Quenchant Cooling Mechanisms*—Upon initial immersion of a heated metal into a solution of an aqueous polymer quenchant, an insulating polymer film, which controls the heat transfer rate from the hot metal into the cooler quenchant solution, forms around the hot metal which is separated by a vapor film (Fig. 3) (**7**) for the quenching process in a poly(alkylene glycol) quenchant. The overall heat transfer mediating properties of the film are dependent on both the film thickness (a function of polymer concentration) and interfacial film viscosity (a function of polymer type and bath temperature). The timing of film formation and subsequent film rupture and removal is dependent on the film strength of the polymer, agitation (both direction and mass flow), and turbulence of the polymer solution surrounding the cooling metal.



NOTE 1—From Wolfson Engineering Group Specification, available from Wolfson Heat Treatment Centre, Aston University, Aston Triangle, Birmingham B4 7ET, England, 1980.

FIG. 2 Schematic Illustration of the Probe Details and Probe Assembly

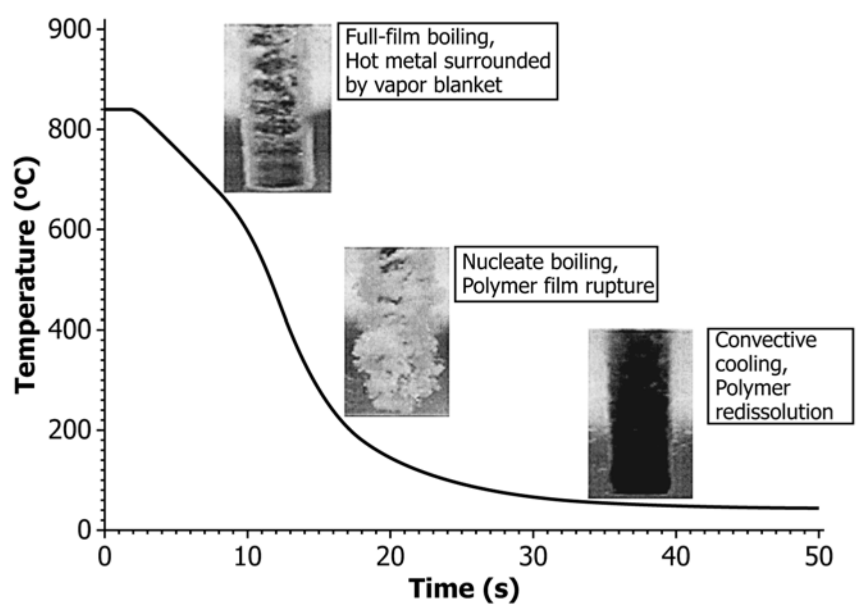


FIG. 3 Illustration of the Three Phases of Cooling

5.1.1 The cooling process that occurs upon initial immersion of the hot metal into the aqueous polymer quenchant is full-film boiling. This is frequently referred to as the vapor blanket stage. Cooling is slowest in this region. When the metal has cooled sufficiently, the polymer film encapsulating the hot metal ruptures and a nucleate boiling process results. The temperature at the transition from full-film boiling to nucleate boiling is called the Leidenfrost temperature. Cooling is fastest in this region. When the surface temperature of the cooling metal is less than the boiling temperature of water, convective cooling results. All three cooling mechanisms are superimposed on a cooling curve and illustrated in Fig. 3. (**7**)

6. Sampling

6.1 *Sampling*—Flow is never uniform in agitated quench tanks. There is always variation of flow rate and turbulence from top to bottom and across the tank. This means there may be significant variations of particulate contamination including