Designation: E1209 – 18

Standard Practice for Fluorescent Liquid Penetrant Testing Using the Water-Washable Process[1]

This standard is issued under the fixed designation E1209; 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[2] covers procedures for water-washable fluorescent penetrant testing of materials. It is a nondestructive testing method for detecting discontinuities that are open to the surface such as cracks, seams, laps, cold shuts, laminations, isolated porosity, through leaks, or lack of porosity and is applicable to in-process, final, and maintenance examination. It can be effectively used in the examination of nonporous, metallic materials, both ferrous and nonferrous, and of nonmetallic materials such as glazed or fully densified ceramics and certain nonporous plastics and glass.

1.2 This practice also provides a reference:

1.2.1 By which a fluorescent penetrant testing method using the water-washable process recommended or required by individual organizations can be reviewed to ascertain its applicability and completeness.

1.2.2 For use in the preparation of process specifications dealing with the water-washable fluorescent penetrant examination of materials and parts. Agreement by the purchaser and the manufacturer regarding specific techniques is strongly recommended.

1.2.3 For use in the organization of the facilities and personnel concerned with the liquid penetrant testing.

1.3 This practice does not indicate or suggest standards for evaluation of the indications obtained. It should be pointed out, however, that indications must be interpreted or classified and then evaluated. For this purpose there must be a separate code or specification or a specific agreement to define the type, size, location, and direction of indications considered acceptable, and those considered unacceptable.

1.4 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.5 All areas of this document may be open to agreement between the cognizant engineering organization and the supplier, or specific direction from the cognizant engineering organization (CEO).

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

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D129 Test Method for Sulfur in Petroleum Products (General High Pressure Decomposition Device Method)

D516 Test Method for Sulfate Ion in Water

D808 Test Method for Chlorine in New and Used Petroleum Products (High Pressure Decomposition Device Method)

D1552 Test Method for Sulfur in Petroleum Products by High Temperature Combustion and Infrared (IR) Detection or Thermal Conductivity Detection (TCD)

E165/E165M Practice for Liquid Penetrant Examination for General Industry

E433 Reference Photographs for Liquid Penetrant Inspection

E543 Specification for Agencies Performing Nondestructive Testing

E1219 Practice for Fluorescent Liquid Penetrant Testing Using the Solvent-Removable Process

E1316 Terminology for Nondestructive Examinations

E2297 Guide for Use of UV-A and Visible Light Sources and Meters used in the Liquid Penetrant and Magnetic Particle Methods

[1] This practice is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.03 on Liquid Penetrant and Magnetic Particle Methods.

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[2] For ASME Boiler and Pressure Vessel Code applications see related Test Method SE-1209 in Section II of that Code.

[3] 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.

***A Summary of Changes section appears at the end of this standard**

E3022 Practice for Measurement of Emission Characteristics and Requirements for LED UV-A Lamps Used in Fluorescent Penetrant and Magnetic Particle Testing

2.2 *ASNT Documents:*[4]

Recommended Practice SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing

ANSI/ASNT-CP-189 Qualification and Certification of NDT Personnel

2.3 *ISO Standard:*[5]

ISO 9712 Non-destructive Testing – Qualification and Certification of NDT Personnel

2.4 *AMS Standard:*[6]

AMS 2644 Inspection Material, Penetrant

2.5 *AIA Standard:*[7]

NAS 410 Certification and Qualification of Nondestructive Test Personnel

2.6 *Department of Defense (DoD) Contracts*—Unless otherwise specified, the issue of the documents that are DoD adopted are those listed in the issue of the DoDISS (Department of Defense Index of Specifications and Standards) cited in the solicitation.

2.7 *Order of Precedence*—In the event of conflict between the text of this practice and the references cited herein, the text of this practice takes precedence.

3. Terminology

3.1 *Definitions*—definitions relating to liquid penetrant testing, which appear in Terminology E1316, shall apply to the terms used in this practice.

NOTE 1—Throughout this practice, the term *blacklight* has been changed to *UV-A* to conform with the latest terminology in Terminology E1316. *Blacklight* can mean a broad range of ultraviolet radiation; fluorescent penetrant testing only uses the UV-A range.

4. Summary of Practice

4.1 A liquid penetrant is applied evenly over the surface being examined and allowed to enter open discontinuities. After a suitable dwell time, the excess surface penetrant is removed with water and the surface is dried prior to the application of a dry or nonaqueous developer. A developer is then applied, drawing the entrapped penetrant out of the discontinuity and staining the developer. If an aqueous developer is to be employed, the developer is applied prior to the drying step. The test surface is then examined visually under UV-A radiation in a darkened area to determine the presence or absence of indications. (**Warning—**Fluorescent penetrant testing shall not follow a visible penetrant testing unless the procedure has been qualified in accordance with 9.2, because visible dyes may cause deterioration or quenching of fluorescent dyes.)

NOTE 2—The developer may be omitted by agreement between purchaser and supplier.

4.2 The selection of particular water-washable penetrant process parameters depends upon the nature of the application, condition under which the examination is to be performed, availability of processing equipment, and type of materials to perform the examination. (**Warning—**A controlled method for applying water and disposing of the water is essential.)

4.3 Processing parameters, such as precleaning, penetration time, and wash times, are determined by the specific materials used, the nature of the part under examination (that is, size, shape, surface condition, alloy), and type of discontinuities expected.

5. Significance and Use

5.1 Liquid penetrant testing methods indicate the presence, location, and, to a limited extent, the nature and magnitude of the detected discontinuities. This method is normally used for production inspection of large volumes of parts or structures, where emphasis is on productivity. The method enjoys a wide latitude in applicability when extensive and controlled conditions are available. Multiple levels of sensitivity can be achieved by proper selection of materials and variations in process.

6. Reagents and Materials

6.1 *Liquid Fluorescent Penetrant Testing Materials* (see Note 3) for use in the water-washable process consist of a family of fluorescent water-washable penetrants and appropriate developers and are classified as Type I Fluorescent, Method A—Water-Washable. Penetrants shall conform to AMS 2644 unless approved by the contract or Level III. Intermixing of materials from various manufacturers is not recommended.

NOTE 3—Refer to 8.1 for special requirements for sulfur, halogen, and alkali metal content. (**Warning—**While approved penetrant materials will not adversely affect common metallic materials, some plastics or rubbers may be swollen or stained by certain penetrants.)

6.2 *Water-Washable Penetrants* are designed to be directly water-washable from the surface of the test part after a suitable penetrant dwell time. Because the emulsifier is "built-in" to the water-washable penetrant, it is extremely important to exercise proper process control in removal of excess surface penetrant to assure against overwashing. Water-washable penetrants can be washed out of discontinuities if the rinsing step is too long or too vigorous. Some penetrants are less resistant to overwashing than others.

6.3 *Developers*—Development of penetrant indications is the process of bringing the penetrant out of open discontinuities through blotting action of the applied developer, thus increasing the visibility of the penetrant indications. Several types of developers are suitable for use with the fluorescent penetrant water-washable process. (**Warning—**Aqueous developers may cause stripping of indications if not properly applied and controlled. The procedure shall be qualified in accordance with 9.2.)

[4] Available from The American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Lane, Columbus, OH 43228-0518.

[5] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[6] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.

[7] Available from Aerospace Industries Association (AIA), 1000 Wilson Blvd., Suite 1700, Arlington, VA 22209, http://www.aia-aerospace.org.

6.3.1 *Dry Powder Developers* are used as supplied (that is, free-flowing, noncaking powder) in accordance with 7.1.7.1(a). Care should be taken not to contaminate the developer with fluorescent penetrant, as the specks can appear as indications.

6.3.2 *Aqueous Developers* are normally supplied as dry powder particles to be either suspended or dissolved (soluble) in water. The concentration, use, and maintenance shall be in accordance with the manufacturer's recommendations (see 7.1.7.1(b)).

6.3.3 *Nonaqueous, Wet Developers* are supplied as suspensions of developer particles in nonaqueous, solvent carriers ready for use as supplied. Nonaqueous, wet developers form a coating on the surface of the part when dried, which serves as the developing medium for fluorescent penetrants (see 7.1.7.1(c)). (**Warning—**This type of developer is intended for application by spray only.)

6.3.4 *Liquid Film Developers* are solutions or colloidal suspensions of resins/polymer in a suitable carrier. These developers will form a transparent or translucent coating on the surface of the part. Certain types of film developer will fix indications and may be stripped from the part and retained for record purposes (see 7.1.7.1(d)).

7. Procedure

7.1 The following general procedure applies to the fluorescent penetrant testing water-washable method (see Fig. 1).

7.1.1 *Temperature Limits*—The temperature of the penetrant materials and the surface of the part to be processed should be between 40° and 125°F (4° and 52°C). Where it is not practical to comply with these temperature limitations, qualify the procedure at the temperature of intended use as described in 9.2.

7.1.2 *Surface Conditioning Prior to Penetrant Inspection*—Satisfactory results can usually be obtained on surfaces in the as-welded, as-rolled, as-cast, or as-forged conditions or for ceramics in the densified condition. The more sensitive penetrants are generally less easily rinsed away and are therefore less suitable for rougher surfaces. When only loose surface residuals are present, these may be removed by wiping the surface with clean lint-free cloths. However, precleaning of metals to remove processing residuals such as oil, graphite, scale, insulating materials, coatings, and so forth, should be done using cleaning solvents, vapor degreasing, or chemical removing processes. Surface conditioning by grinding, machining, polishing, or etching shall follow shot, sand, grit, and vapor blasting to remove the peened skin and when penetrant entrapment in surface irregularities might mask the indications of unacceptable discontinuities or otherwise interfere with the effectiveness of the examination. For metals, unless otherwise specified, etching shall be performed when evidence exists that previous cleaning, surface treatments, or service usage have produced a surface condition that degrades

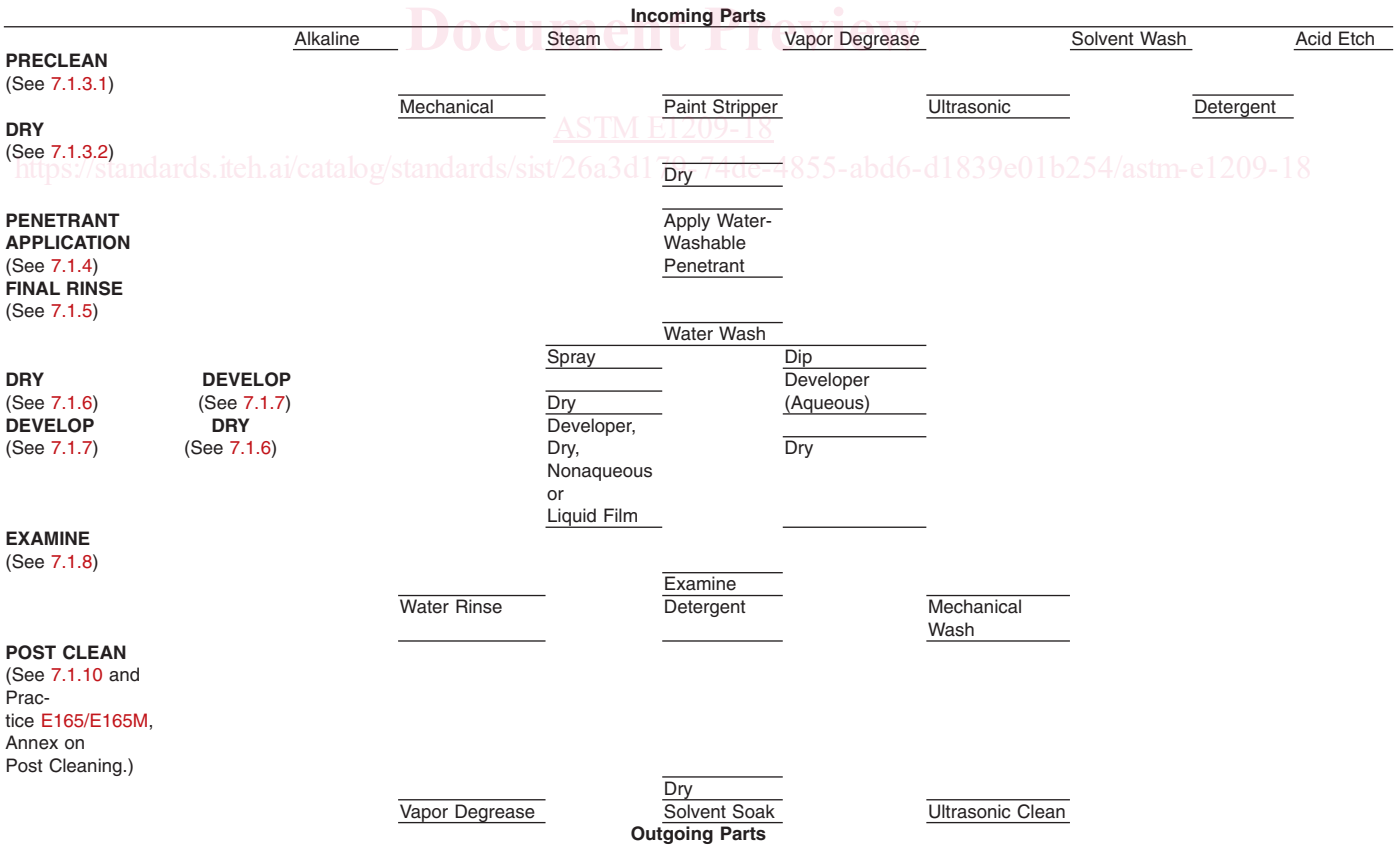

FIG. 1 General Procedure Flowsheet for Fluorescent Penetrant Testing Using the Water-Washable Process

the effectiveness of the examination. (See Annex on Cleaning Parts and Materials in Practice E165/E165M for general precautions relative to surface preparation.)

NOTE 4—When agreed between purchaser and supplier, grit blasting without subsequent etching may be an acceptable cleaning method. (**Warning—**Sand or shot blasting may possibly close indications and extreme care should be used with grinding and machining operations.)

NOTE 5—For structural or electronic ceramics, surface preparation by grinding, sand blasting, and etching for penetrant testing is not recommended because of the potential for damage.

7.1.3 *Removal of Surface Contaminants:*

7.1.3.1 *Precleaning*—The success of any penetrant testing procedure is greatly dependent upon the surface and discontinuity being free of any contaminant (solid or liquid) that might interfere with the penetrant process. All parts or areas of parts to be examined must be clean and dry before the penetrant is applied. If only a section of a part, such as weld including the heat-affected zone, is to be examined, all contaminants shall be removed from the area being examined as defined by the contracting parties. "Clean" is intended to mean that the surface must be free of any rust, scale, welding flux, spatter, grease, paint, oily films, dirt, etc., that might interfere with penetration. All of these contaminants can prevent the penetrant from entering discontinuities. (See Annex on Cleaning of Parts and Materials in Practice E165/E165M for more detailed cleaning methods.) (**Warning—**Residues from cleaning processes such as strong alkalies, pickling solutions, and chromates, in particular, may adversely react with the penetrant and reduce its sensitivity and performance.)

7.1.3.2 *Drying After Cleaning*—It is essential that the surfaces be thoroughly dry after cleaning, since any liquid residue will hinder the entrance of the penetrant. Drying may be accomplished by warming the parts in drying ovens, with infrared lamps, forced hot or cold air, or by exposure to ambient temperature.

7.1.4 *Penetrant Application*—After the part has been cleaned, dried, and is within the specified temperature range, apply the penetrant to the surface to be examined so that the entire part or area under examination is completely covered with penetrant.

7.1.4.1 *Modes of Application*—There are various modes of effective application of penetrant such as dipping, brushing, flooding, or spraying. Small parts are quite often placed in suitable baskets and dipped into a tank of penetrant. On larger parts, and those with complex geometries, penetrant can be applied effectively by brushing or spraying. Both conventional and electrostatic spray guns are effective means of applying liquid penetrants to the part surfaces. Electrostatic spray application can eliminate excess liquid buildup of penetrant on the surface, minimize overspray, and minimize the amount of penetrant entering hollow-cored passages which might serve as penetrant reservoirs, causing severe bleedout problems during examination. Aerosol sprays are conveniently portable and suitable for local application. (**Warning—**Not all penetrant materials are suitable for electrostatic spray applications.) (**Warning—**With spray applications, it is important that there be proper ventilation. This is generally accomplished through the use of a properly designed spray booth and exhaust system.)

NOTE 6—For some specific applications in structural ceramics (for example, detecting parting lines in slip-cast material), the required penetrant dwell time should be determined experimentally and may be longer than that shown in Table 1 and its notes.

7.1.4.2 *Penetrant Dwell Time*—After application, allow excess penetrant to drain from the part (care should be taken to prevent pools of penetrant on the part), while allowing for proper penetrant dwell time (see Table 1). The length of time the penetrant must remain on the part to allow proper penetration should be as recommended by the penetrant manufacturer. Table 1, however, provides a guide for selection of penetrant dwell times for a variety of materials, forms, and types of discontinuity. Unless otherwise specified, the dwell time shall not exceed the maximum recommended by the manufacturer.

7.1.5 *Removal of Excess Penetrant*—After the required penetration time, the excess penetrant on the surface being examined must be removed with water, usually a washing operation. It can be washed off manually, by the use of automatic or semiautomatic water-spray equipment, or by immersion. Accumulation of water in pockets or recesses of the surface must be avoided. If over-removal is suspected, dry (see 7.1.6) and reclean the part, then reapply the penetrant for the prescribed dwell time. (**Warning—**Avoid overwashing. Excessive washing can cause penetrant to be washed out of discontinuities. Perform the rinsing operation under UV-A radiation so that it can be determined when the surface penetrant has been adequately removed.) The CEO may specify maximum wash times.

7.1.5.1 *Immersion Rinsing*—For immersion rinsing, parts are completely immersed in the water bath with air or mechanical agitation. Final rinsing of water-washable, fluorescent penetrants by spray application can be accomplished by either manual or automatic water spray rinsing of the parts.

(a) Rinse time—Maximum should be specified by part or material specification with consideration to prevent the washing out of penetrant from discontinuities.

TABLE 1 Recommended Minimum Dwell Times

Material	Form	Type of Discontinuity	Dwell Times[A] (min)	
			Penetrant[B]	Developer[C]
Aluminum, magnesium, steel, brass and bronze, titanium and high-temperature alloys	castings and welds	cold shuts, porosity, lack of fusion, cracks (all forms)	5	10
	wrought-materials—extrusions, forgings, plate	laps, cracks (all forms)	10	10
Carbide-tipped tools		lack of fusion, porosity, cracks	5	10
Plastic	all forms	cracks	5	10
Glass	all forms	cracks	5	10
Ceramic	all forms	cracks, porosity	5	10

[A] For temperature range from 40° to 125°F (4° to 52°C).
[B] Maximum penetrant dwell time 60 min in accordance with 7.1.4.2.
[C] Development time begins as soon as wet developer coating has dried on surface of parts (recommended minimum). Maximum development time in accordance with 7.1.7.2.