Designation: E1418 – 21

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

This standard is issued under the fixed designation E1418; 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 describes procedures for visible liquid penetrant examination utilizing the water-washable process. It is a nondestructive practice for detecting discontinuities that are open to the surface such as cracks, seams, laps, cold shuts, laminations, isolated porosity, through leaks or lack of fusion and is applicable to in-process, final, and maintenance examination. This practice 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 the following references:

1.2.1 A reference by which visible penetrant examination procedures using the water-washable process can be reviewed to ascertain their applicability and completeness.

1.2.2 For use in the preparation of process specifications dealing with the visible, water-washable liquid penetrant examination of materials and parts. Agreement between the user and the supplier regarding specific techniques is strongly recommended.

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

1.3 This practice does not indicate or suggest criteria for evaluation of the indications obtained. It should be noted, however, that after indications have been produced, they must be interpreted or classified and then evaluated. For this purpose there must be a separate code, specification, or a specific agreement to define the type, size, location, and orientation of indications considered acceptable, and those considered unacceptable.

1.3.1 The user is encouraged to use materials and processing parameters necessary to detect conditions of a type or severity which could affect the evaluation of the product.

1.4 *Units*—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 *Basis of Application*—There are areas in this practice that may require agreement between the cognizant engineering organization and the supplier, or specific direction from the cognizant engineering organization. These areas are identified as follows:

1.5.1 Penetrant type, method and sensitivity,
1.5.2 Accept/reject criteria,
1.5.3 Personnel qualification requirements,
1.5.4 Grit blasting,
1.5.5 Etching,
1.5.6 Indication/discontinuity sizing,
1.5.7 Total processing time, and
1.5.8 Marking of parts.

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:*[2]

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)

[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 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.

E165/E165M Practice for Liquid Penetrant Testing 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

2.2 *ASNT Standards:*[3]
Recommended Practice SNT-TC-1A for Nondestructive Testing Personnel Qualification and Certification
ANSI/ASNT-CP-189 Standard for Qualification and Certification of NDT Personnel

2.3 *Other Standards:*
ISO 9712 Non-destructive Testing—Qualification and Certification of NDT Personnel—General Principles[4]
AMS 2644 Inspection Material, Penetrant[5]

2.4 *AIA Standard:*[6]
NAS410 Certification and Qualification of Nondestructive Test Personnel

2.5 *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.

2.6 *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:*

3.1.1 The definitions relating to liquid penetrant examination that appear in Terminology E1316, shall apply to the terms used in this practice.

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 developer. A developer is then applied, drawing the entrapped penetrant out of the discontinuities and staining the developer. If an aqueous developer is to be employed, the developer is applied prior to the drying step. After application of the developer, a suitable development time is allowed to permit the entrapped penetrant to exit from the discontinuities. The test surface is then examined visually under adequate illumination to determine the presence or absence of indications.

4.2 The selection of specific water-washable penetrant process parameters depends upon the nature of the application, conditions 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 examination methods indicate the presence, location, and, to a limited extent, the nature and magnitude of the detected discontinuities. This practice is normally used for production examination of large volumes of parts or structures, where emphasis is on productivity. This practice offers a wide latitude in applicability when extensive and controlled conditions are available.

6. Reagents and Materials

6.1 *Visible, Water-Washable Liquid Penetrant Testing Materials,* consisting of applicable visible penetrants as recommended by the manufacturer, and are classified as Type II Visible Method A—Water-Washable (see Note 1). Penetrant materials shall conform to AMS 2644 unless approved by the contract or Level III. (**Warning—**While approved penetrant materials will not adversely affect common metallic materials, some plastics or rubber may be swollen or stained by certain penetrants.)

NOTE 1—Refer to 8.1 for special requirements for sulfur, halogen, and alkali metal content.

6.2 *Water-Washable Penetrants,* designed to be directly water-washable from the surface of the 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 removing excess penetrant to ensure against overwashing. Water-washable penetrants can be washed out of discontinuities if the washing 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 the blotting action of the applied developer, thus increasing the visibility of the penetrant indications. The developer used shall provide a contrasting white background. Several types of developers are suitable for use in the visible penetrant water-washable process.

6.3.1 *Aqueous Developers,* 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). (**Warning—**Aqueous developers may cause stripping of indications, if not properly applied and controlled. The procedure should be qualified in accordance with 9.2.)

[3] Available from The American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Lane, Columbus, OH 43228-0518.
[4] Available from International Organization for Standardization (ISO), ISO Central Secretariat, BIBC II, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, http://www.iso.org.
[5] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.
[6] Available from the Aerospace Industries Association of America, Inc., 1250 Eye Street, N.W., Washington, DC 20005.

6.3.2 *Nonaqueous, Wet Developers,* normally supplied as suspensions of developer particles in a volatile solvent carrier and are ready for use as supplied. They are applied to the surface by spraying after the excess penetrant has been removed and the surface has dried. Nonaqueous wet developers form a white coating on the surface of the part when dried and serve as a contrasting background for visible penetrants (see 7.1.7.2). (**Warning—**This type of developer is intended for application by spray only.)

7. Procedure

7.1 The following general procedures applies to the water-washable, visible penetrant examination 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 from 40 to 125 °F (4 to 52 °C). When it is not practical to comply with these temperature limitations, the procedure must be qualified at the temperature of intended use as described in 9.2.

7.1.2 *Surface Conditioning Prior to Penetrant Examination*—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). When only loose surface residuals are present, these may be removed by wiping with a clean lint-free cloth. However, pre-cleaning of metals to remove processing residuals such as oil, graphite, scale, insulating materials, coatings, etc. 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, perform etching when evidence exists that previous cleaning, surface treatments, or service usage have produced a surface condition that degrades the effectiveness of penetrant examination. (See Annex A1.1.1.8 in Practice E165/E165M for precautions).

NOTE 2—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 3—For structural or electronic ceramics, surface preparation by grinding, sand blasting and etching for penetrant examination 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 examination 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

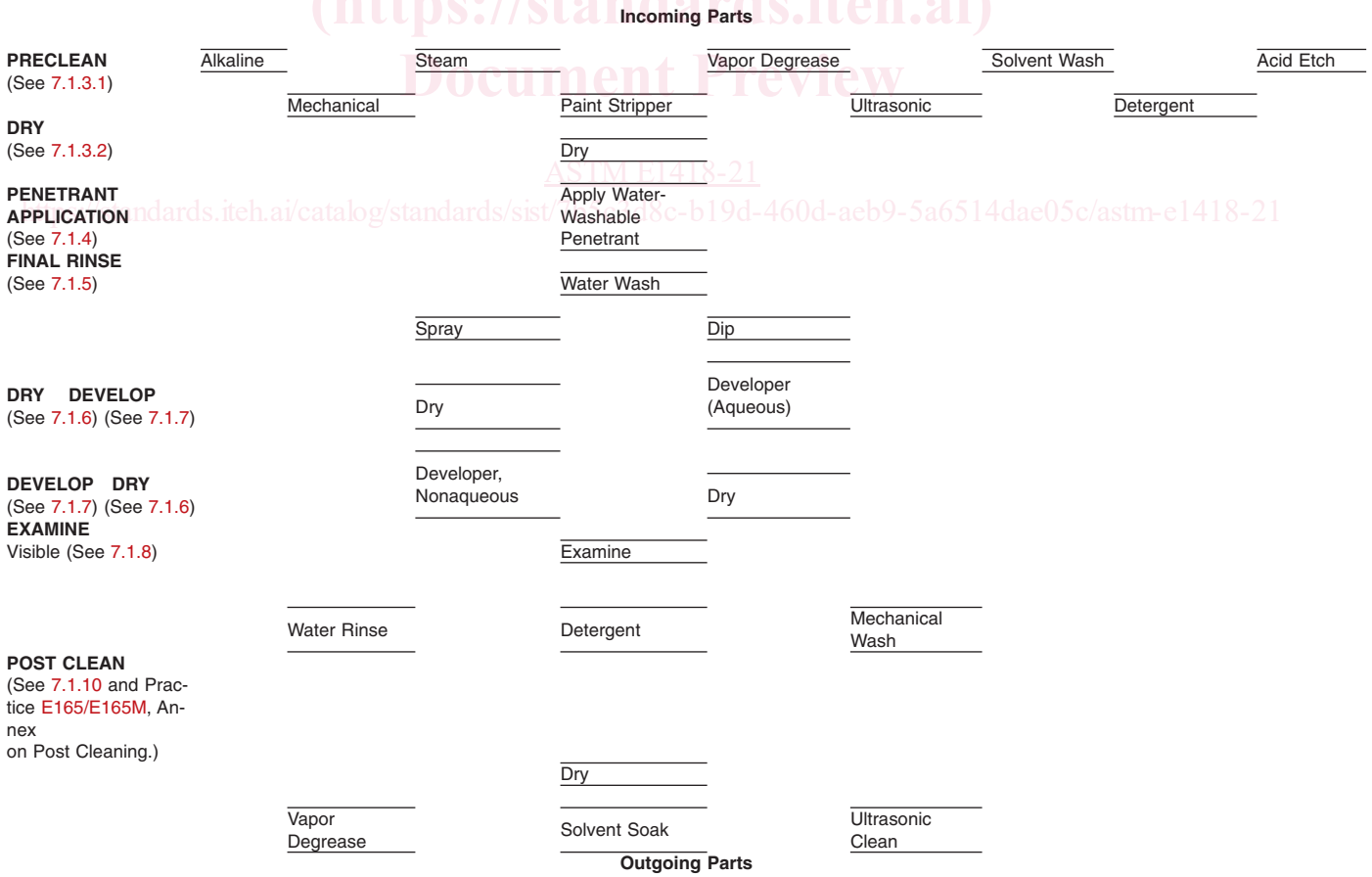

FIG. 1 General Procedure Flowsheet for Visible Penetrant Examination Using the Water-Washable Process

penetrant is applied. If only a section of a part, such as weld, including the heat affected zone is to be examined, remove all contaminants from the area being examined as defined by the contracting parties. "Clean" is intended to mean that the surface must be free of 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 the 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 Applications*—After the area to be examined 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 immersion, 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 appropriate means of applying liquid penetrants to the part surfaces. Electrostatic spray application can eliminate excess liquid build-up of penetrant on the surface, minimize overspray, and minimize the amount of penetrant entering hollow-cored passages that might serve as penetrant reservoirs, causing severe bleedout problems during examination. Aerosol sprays are also very effective and a convenient portable means of application. (**Warning—**Not all penetrant materials are suitable for electrostatic spray applications, so tests should be conducted prior to use.) (**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 or exhaust system, or both.)

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, their form, and types of discontinuities.

NOTE 4—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.

7.1.5 *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 semi-automatic water-spray equipment or by immersion. Accumulation of water in pockets or recesses of the surface must be avoided. If the final rinse step is not effective, as evidenced by difficulty in removing the excess penetrant, 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.)

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

(a) Maximum rinse time should be specified by part or material specification.

(b) The temperature of the water should be relatively constant and should be maintained within the range of 50 to 100 °F (10 to 38 °C).

(c) Spray rinse water pressure should not be greater than 40 psi (280 kPa).

7.1.5.2 *Removal by Wiping*—In special applications, penetrant removal may be performed by wiping the surface with a clean, absorbent material dampened with water until the excess surface penetrant is removed, as determined by visual examination. This process shall be performed in accordance with E1219. A solvent cleaner may be used instead of water to wipe off excess penetrant.

TABLE 1 Recommended Minimum Dwell Times

Material	Form	Type of Discontinuity	Dwell Times[A] (minutes)	
			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 not to exceed penetrant manufacturer recommendation 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). Minimum development time in accordance with 7.1.7.2.