Designation: E1209 – 10

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 examination 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 examination 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 examination.

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 regarded as standard. SI units given in parentheses are for information only.

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.

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

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 (High-Temperature Method)

E165 Practice for Liquid Penetrant Examination for General Industry

E433 Reference Photographs for Liquid Penetrant Inspection

E543 Specification for Agencies Performing Nondestructive Testing

E1316 Terminology for Nondestructive Examinations

2.2 *ASNT Documents:*

Recommended Practice SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing[4]

ANSI/ASNT-CP-189 Qualification and Certification of NDT Personnel[4]

2.3 *Military Standard:*[5]

MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification

[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.

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

[5] Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

2.4 *AIA Standard:*
NAS 410 Certification and Qualification of Nondestructive Test Personnel[6]

2.5 *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.

2.6 *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*—definitions relating to liquid penetrant examination, which 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 tested 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 black light in a darkened area to determine the presence or absence of indications. (**Warning—**Fluorescent penetrant examination shall not follow a visible penetrant examination unless the procedure has been qualified in accordance with 9.2, because visible dyes may cause deterioration or quenching of fluorescent dyes.)

NOTE 1—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 examination 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 2) 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. Intermixing of materials from various manufacturers is not recommended.

NOTE 2—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 and 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.)

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)).

[6] Available from the Aerospace Industries Association of America, Inc., 1250 Eye Street, N.W., Washington, DC 20005.

7. Procedure

7.1 The following general procedure applies to the fluorescent penetrant examination 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 the effectiveness of the examination. (See Annex on Mechanical Cleaning and Surface Conditioning and Annex on Acid Etching in Test Method E165 for general precautions relative to surface preparation.)

NOTE 3—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 4—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 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

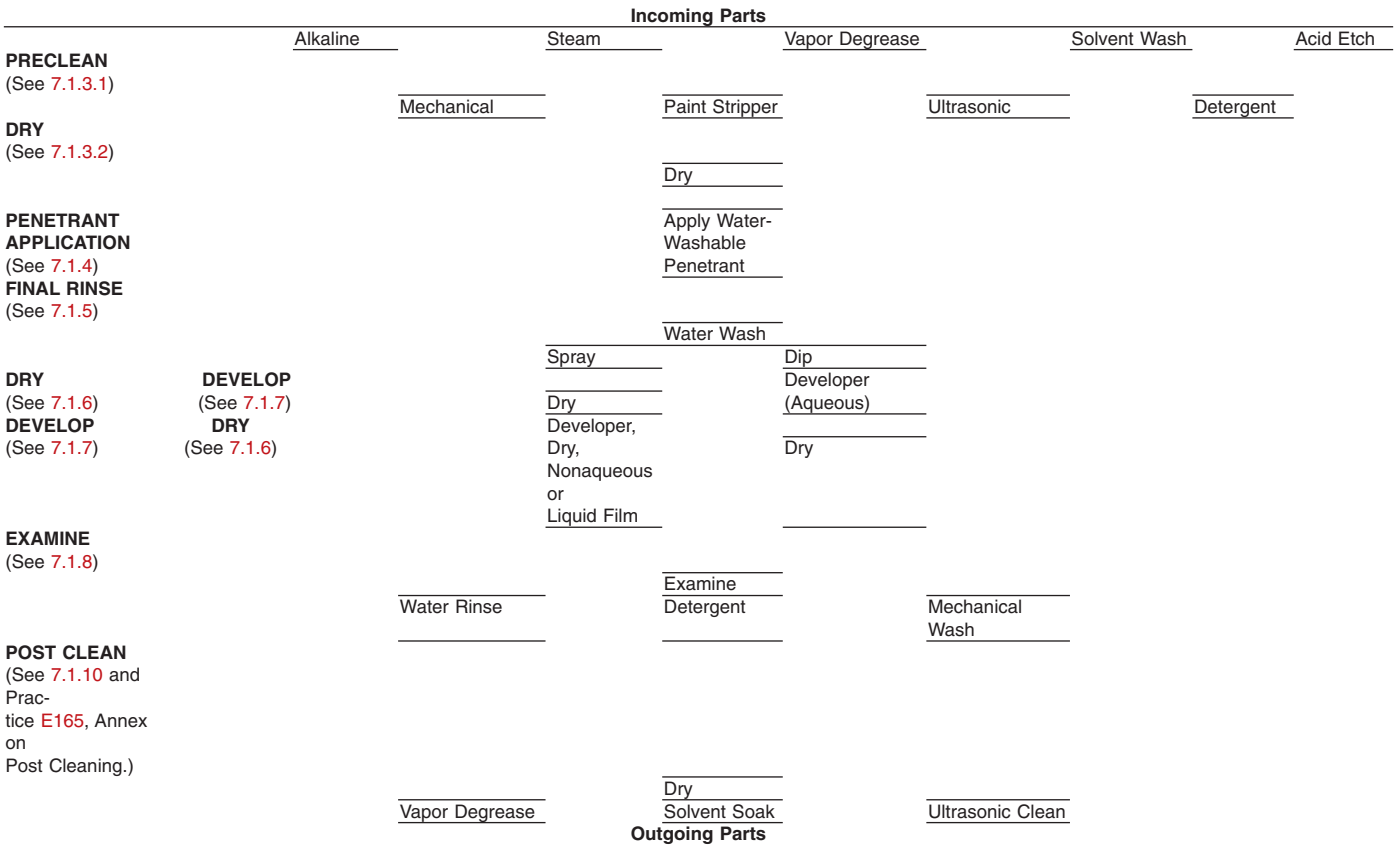

FIG. 1 General Procedure Flowsheet for Fluorescent Penetrant Examination Using the Water-Washable Process

penetrant from entering discontinuities. (See Annex on Cleaning of Parts and Materials in Test Method E165 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 inspected 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 5—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 black light so that it can be determined when the surface penetrant has been adequately removed.)

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 120°F (4° to 49°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.

7.1.5.1 *Immersion Rinsing*—For immersion rinsing, parts are completely immersed in the water bath with air or mechanical agitation. Effective 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.

(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 (275 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 examination under black light.

7.1.6 *Drying*—During the preparation of parts for examination, drying is necessary following the application of the aqueous, wet developer or prior to applying dry or nonaqueous developers. Drying time will vary with the size, nature, and number of parts under examination.

7.1.6.1 *Modes of Drying*—Parts can be dried by using a hot-air recirculating oven, a hot- or cold-air blast, or by exposure to ambient temperature. Drying is best done in a thermostatically controlled recirculating hot-air dryer. (**Warning—**Drying oven temperature should not exceed 160°F (71°C).)

7.1.6.2 *Drying Time Limits*—Do not allow parts to remain in the drying oven any longer than is necessary to dry the part. Excessive time in the dryer may impair the sensitivity of the examination.

7.1.7 *Developer Application:*

7.1.7.1 There are various modes of effective application of the various types of developers such as dusting, immersing, flooding, or spraying. The size, configuration, surface condition, number of parts to be processed, etc., will influence the choice of developer application.

(a) *Dry Powder Developer*—Apply dry powder developers immediately after drying in such a manner as to assure complete coverage. Parts can be immersed into a container of dry developer or into a fluid bed of dry developer. They can also be dusted with the powder developer using a hand powder bulb or a conventional or electrostatic powder gun. It is quite common and most effective to apply dry powder in an enclosed dust chamber, which creates an effective and controlled dust cloud. Other means suited to the size and geometry of the specimen may be used provided the powder is dusted evenly over the entire surface being examined. Excess powder may be removed by gently shaking or tapping the part, or by blowing with low-pressure not exceeding (5 psi (34 kPa)) dry, clean compressed air. (**Warning—**The air stream intensity should be established experimentally for each application.)

(b) *Aqueous Developers*—Apply aqueous developers to the part immediately after the excess penetrant has been removed from the part and prior to drying. The dried developer coating appears as a translucent or white coating on the part. Prepare and maintain aqueous, wet developers in accordance with the manufacturer's instructions and apply them in such a manner as to assure complete, even coverage. Exercise caution when using a wet developer with water-washable penetrants to avoid possible stripping of indications. Aqueous developers may be applied by spraying, flowing, or immersing the part. Atomized spraying is not recommended since a spotty film may result. It is most common to immerse the parts in the prepared developer bath. Immerse parts only long enough to coat all of the part surfaces with the developer, since if parts are left in bath too long, indications may leach out. Then remove parts from the developer bath immediately and allow to drain. Drain all excess developer from recesses and trapped sections to eliminate pooling of developer, which can obscure discontinuities. Dry the parts in accordance with 7.1.6.

(c) *Nonaqueous, Wet Developers*—Nonaqueous, wet developer carriers evaporate very rapidly at normal room temperature and do not, therefore, require the use of a dryer. After the excess penetrant has been removed and the surface has been dried, apply these developers to the surface by spraying in such a manner as to ensure complete coverage with a thin, even film of developer. Application of excessive developer should be avoided. Dipping or flooding parts with nonaqueous, wet developers is prohibited, since it will flush (dissolve) the penetrant from within the discontinuities because of the solvent action of these types of developers. (**Warning—**The vapors from the evaporating, volatile, solvent developer carrier may be hazardous. Proper ventilation should be provided in all cases, but especially when the surface to be examined is inside a closed volume such as a process drum or a small storage tank.)

(d) *Liquid Film Developers*—Apply by spraying or dipping as recommended by the manufacturer. Spray parts in such a manner as to ensure complete coverage of the area being examined with a thin, even film of developer.

(e) *No Developer*—For certain applications, it is permissible, and may be appropriate, to conduct this examination without the use of developer.

7.1.7.2 *Developer Time*—The minimum and maximum penetrant bleedout time with no developer shall be 10 min and 2 h respectively. Developing time for dry developer begins immediately after the application of the dry developer and begins when the developer coating has dried for wet developers (aqueous and nonaqueous). The minimum developer dwell time shall be 10 min for all types of developer. The maximum developer dwell time shall be 1 h for nonaqueous developer, 2 h for aqueous developer and 4 h for dry developers.

7.1.8 *Examination*—Perform examination of parts after the applicable development time as specified in 7.1.7.2 to allow for bleedout of penetrant from discontinuities onto the developer coating. It is good practice to observe the surface while applying the developer as an aid in evaluating indications.

7.1.8.1 *Visible Ambient Light Level*—Examine fluorescent penetrant indications under black light in a darkened area. Visible ambient light should not exceed 2 fc (20 lux). The measurement should be made with a suitable photographic-type visible-light meter on the surface being examined.

7.1.8.2 *Black Light Level*—Black light intensity, (recommended minimum of 1000 $\mu W/cm^2$) should be measured on the surface being examined with a suitable black light meter. The black light shall have a wavelength in the range from 320 to 380 nm. The intensity should be checked daily to assure the required output. Since a drop in line voltage can cause decreased black light output with consequent inconsistent performance, a constant voltage transformer should be used when there is evidence of voltage fluctuation. (**Warning—**Certain high-intensity black lights may emit unacceptable amounts of visible light, which will cause fluorescent indications to disappear. Care should be taken to use only bulbs certified by the supplier to be suitable for such examination purposes.)

7.1.8.3 *Black Light Warm-Up*—Allow the black light to warm up for a minimum of 10 min prior to its use or measurement of the intensity of the ultraviolet light emitted.

7.1.8.4 *Visual Adaptation*—The examiner should be in the darkened area for at least 1 min before examining parts. Longer times may be necessary for more complete adaptation under some circumstances. (**Warning—**Photochromic or darkened lenses shall not be worn during examination.)

7.1.8.5 *Housekeeping*—Keep the examination area free of interfering debris or fluorescent objects. Practice good housekeeping at all times.

7.1.9 *Evaluation*—Unless otherwise agreed upon, it is normal practice to interpret and evaluate the discontinuity indication based on the size of the penetrant indication created by the developer's absorption of the penetrant (see Reference Photographs E433).

7.1.10 *Post Cleaning*—Post cleaning is necessary in those cases where residual penetrant or developer could interfere with subsequent processing or with service requirements. It is particularly important where residual penetrant examination materials might combine with other factors in service to produce corrosion. A suitable technique, such as a simple water rinse, water spray, machine wash, vapor degreasing, solvent soak, or ultrasonic cleaning may be employed (see Test Method E165, Annex on Post Cleaning). It is recommended that if developer removal is necessary, it shall be carried out as promptly as possible after examination so that it does not fix on the part. Water spray rinsing is generally adequate. (**Warning—**Developers should be removed prior to vapor degreasing. Vapor degreasing can bake developer on parts.)

8. Special Requirements

8.1 *Impurities:*

8.1.1 When using penetrant materials on austenitic stainless steels, titanium, nickel-base, or other high-temperature alloys, the need to restrict impurities such as sulfur, halogens, and alkali metals must be considered. These impurities may cause embrittlement or corrosion, particularly at elevated temperatures. Any such evaluation should also include consideration of the form in which the impurities are present. Some penetrant materials contain significant amounts of these impurities in the form of volatile organic solvents. These normally evaporate quickly and usually do not cause problems. Other materials may contain impurities that are not volatile and may react with the part, particularly in the presence of moisture or elevated temperatures.

8.1.2 Because volatile solvents leave the tested surface quickly without reaction under normal inspection procedures, penetrant materials are normally subjected to an evaporation procedure to remove the solvents before the materials are analyzed for impurities. The residue from this procedure is then analyzed by Test Method D129, Test Method D1552, or Test Method D129 decomposition followed by Test Methods D516, Method B (Turbidimetric Method) for sulfur. The residue may also be analyzed by Test Methods D808 or E165, Annex on Methods for Measuring Total Chlorine Content in Combustible Liquid Penetrant Materials (for halogens other than fluorine) and Test Method E165, Annex on Method for Measuring Total Fluorine Content in Combustible Liquid Penetrant Materials (for fluorine). The Annex on Determination of Anions and Cations by Ion Chromatography in Test Method E165 can be used as an alternate procedure. Alkali metals in the residue are determined by flame photometry or atomic absorption spectrophotometry.

NOTE 6—Some current standards indicate that impurity levels of sulfur and halogens exceeding 1 % of any one suspect element are considered excessive. However, this high a level may be unacceptable in some cases, so the actual maximum acceptable impurity level must be decided between supplier and user on a case by case basis.

8.2 *Elevated Temperature Examination*—Where penetrant examination is performed on parts that must be maintained at elevated temperature during examination, special materials and processing techniques may be required. Such examination requires qualification in accordance with 9.2. Manufacturer's recommendations should be observed.

9. Qualification and Requalification

9.1 *Personnel Qualification*—Unless otherwise specified by client/supplier agreement, all examination personnel shall be qualified/certified in accordance with a written practice conforming to the applicable edition of Recommended Practice SNT-TC-1A, ANSI/ASNT-CP-189, NAS-410 or MIL-STD-410.

9.2 *Procedure Qualification*—Qualification of procedure using conditions or times differing from those specified or for new materials may be performed by any of several methods and should be agreed upon by the contracting parties. A test piece containing one or more discontinuities of the smallest relevant size is used. The test piece may contain real or simulated discontinuities, providing it displays the characteristics of the discontinuities encountered in production examinations.

9.3 *Nondestructive Testing Agency Qualification*—If a nondestructive testing agency as described in Practice E543 is used to perform the examination, the agency shall meet the requirements of Practice E543.

9.4 *Requalification*—may be required when a change or substitution is made in the type of penetrant materials or in the procedure (see 9.2).

10. Keywords

10.1 fluorescent liquid penetrant testing; nondestructive testing; water-washable method