Designation: E1219 – 16

Standard Practice for Fluorescent Liquid Penetrant Testing Using the Solvent-Removable Process[1]

This standard is issued under the fixed designation E1219; 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 fluorescent penetrant examination utilizing the solvent-removable process. 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 fusion 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 solvent-removable 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 fluorescent solvent-removable liquid 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 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.

1.5 The values stated in inch-pound units are regarded as standard. SI units given in parentheses are for information only.

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 by High Temperature Combustion and IR Detection
E165/E165M 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
E2297 Guide for Use of UV-A and Visible Light Sources and Meters used in the Liquid Penetrant and Magnetic Particle Methods
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:*

Recommended Practice SNT-TC-1A Personnel Qualification and Certification in Nondestructive Testing[4]
ANSI/ASNT-CP-189 Qualification and Certification of NDT Personnel[4]

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[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-1219 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.

2.3 *ISO Standard:*[5]

ISO 9712 Nondestructive Testing—Qualification and Certification of NDT Personnel—General Principles

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.

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

4. Summary of Practice

4.1 A liquid, fluorescent 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 and the surface is dried prior to the application of a dry, nonaqueous, wet, or liquid film developer. If an aqueous developer is to be employed, the developer is applied prior to the drying step. The developer draws the entrapped penetrant out of the discontinuity, staining the developer. The surface is then examined visually under black light to determine 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 2—The developer may be omitted by agreement between purchaser and supplier.

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

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 intended primarily for portability and for localized areas of examination, utilizing minimal equipment, when a higher level of sensitivity than can be achieved using visible process is required. Surface roughness may be a limiting factor. If so, an alternative process such as post-emulsified penetrant should be considered, when grinding or machining is not practical.

6. Reagents and Materials

6.1 *Fluorescent Solvent-Removable Liquid Penetrant Testing Materials,* (see Note 3) consist of a family of applicable fluorescent penetrants, solvent removers, as recommended by the manufacturer, and are classified as Type I Fluorescent, Method C—Solvent-Removable. Intermixing of materials from various manufacturers is not recommended. (**Warning—**While approved penetrant materials will not adversely affect common metallic materials, some plastics or rubbers may be swollen or stained by certain penetrants.)

NOTE 3—Refer to 8.1 for special requirements for sulfur, halogen, and alkali metal content.

6.2 *Fluorescent Solvent-Removable Penetrants,* are designed so that excess surface penetrant can be removed by wiping with clean, lint-free material, and repeating the operation until most traces of penetrant have been removed. The remaining traces shall be removed by wiping the surface with clean, lint-free material lightly moistened with the solvent remover. To minimize removal of penetrant from discontinuities, care shall be taken to avoid the use of excess solvent. Flushing the surface with solvent to remove the excess penetrant is prohibited.

6.3 *Solvent Removers* function by dissolving the penetrant, making it possible to wipe the surface clean and free of residual fluorescent penetrant as described in 7.1.5.

6.4 *Developers*—Development of penetrant indications is the process of bringing the penetrant out of discontinuities through blotting action of the applied developer, thus increasing the visibility of the penetrant indications. Nonaqueous, wet developers, and aqueous developers are most commonly used in solvent-removable processes. Liquid film developers also are used for special applications.

6.4.1 *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 manufacturer's recommendations (see 7.1.7.2).

6.4.2 *Nonaqueous, Wet Developers* are supplied as suspensions of developer particles in a nonaqueous 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 translucent or white coating on the surface when dried, and serve as a contrasting background for fluorescent penetrants (see 7.1.7.3). (**Warning—**This type of developer is intended for application by spray only.)

6.4.3 *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

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[5] 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.

[6] Available from the Aerospace Industries Association of America, Inc., 1000 Wilson Blvd, Suite 1700, Arlington, VA 22209-3928.

surface of the part. Certain types of film developer may be stripped from the part and retained for record purposes (see 7.1.7.4).

6.4.4 *Dry Developer*—Dry developer shall be applied in such a manner as to allow contact of all surfaces to be inspected. Excess dry developer may be removed after the development time by light tapping or light air blow off not exceeding 5 psig. Minimum and maximum developer dwell times shall be 10 min to 4 h respectively.

7. Procedure

7.1 The following general procedure (see Fig. 1) applies to the solvent-removable fluorescent penetrant examination method.

7.1.1 *Temperature Limits*—The temperature of the penetrant materials and the surface of the part to be processed should be from 40 and 125°F (4 and 52°C). Where 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 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. 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 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 examination is not recommended because of the potential for damage.

7.1.3 *Removal of Surface Contamination:*

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 inspected must be clean and dry before the

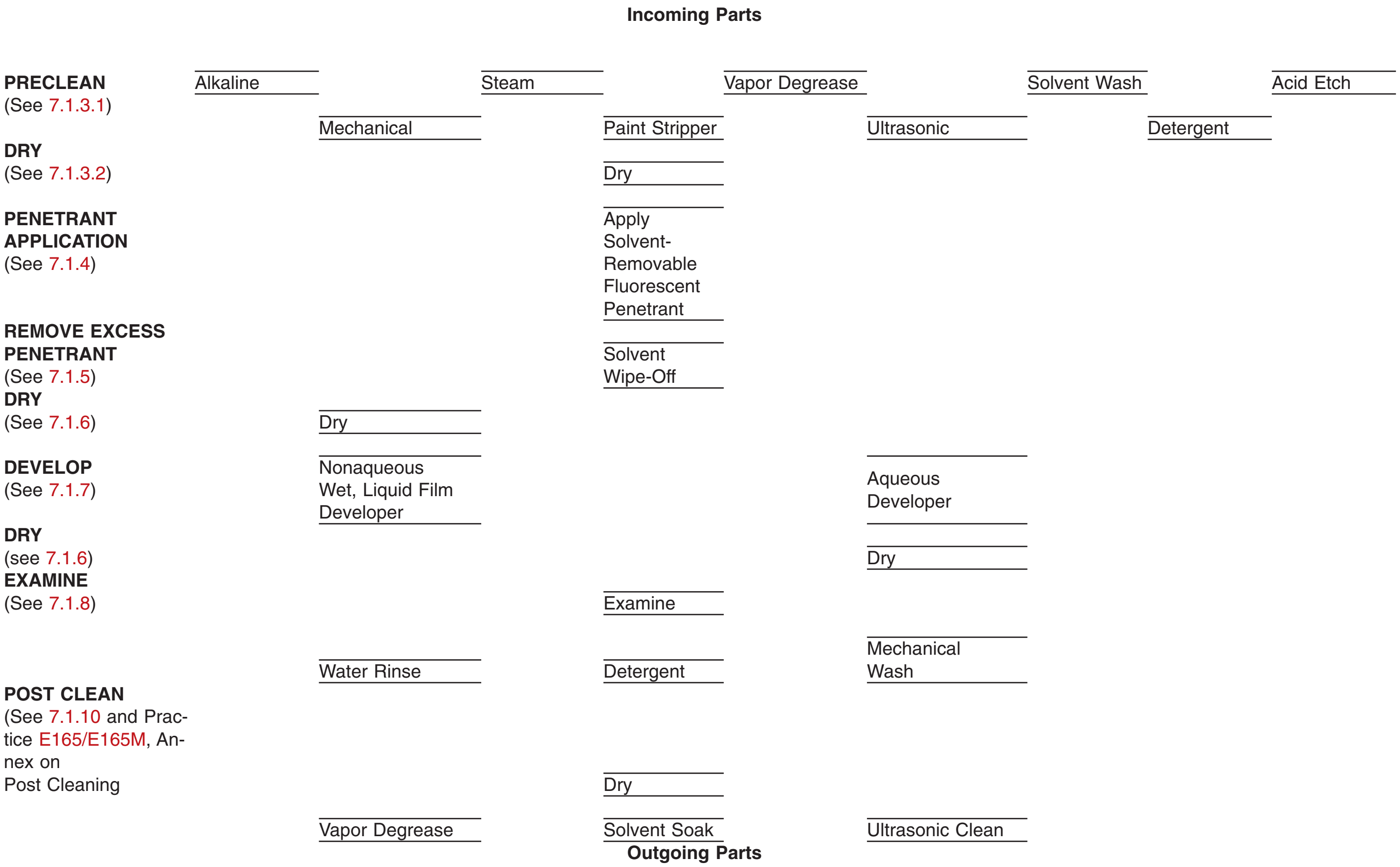

FIG. 1 Solvent-Removable Fluorescent Penetrant Examination General Procedure Flowsheet

penetrant is applied. If only a section of a part, such as a 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 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. (**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 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 part, minimize overspray, and minimize the amount of penetrant entering hollow-cored passages that might serve as penetrant reservoirs and can cause 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.) (**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.)

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, however, the dwell time shall not exceed the maximum recommended by the manufacturer.

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.

7.1.5 *Removal of Excess Penetrant*—After the required penetration time, remove the excess penetrant insofar as possible, by using wipers of a dry, clean, lint-free material, repeating the operation until most traces of penetrant have been removed. Then lightly moisten a lint-free material with solvent remover and wipe the remaining traces gently to avoid the removal of penetrant from discontinuities, taking care to avoid the use of excess solvent. After the solvent wipe, perform a dry wipe to remove solvent residues. If over-removal is suspected, dry (see 7.1.6) and reclean the part, and reapply the penetrant for the prescribed dwell time. Flushing the surface with solvent following the application of the penetrant and prior to developing is prohibited.

7.1.6 *Drying*—Following the removal of excess surface penetrant by solvent wipe-off techniques, the part surface shall be dry and free of solvent residues before application of developer.

NOTE 7—Local heating or cooling is permitted provided the temperature of the part remains in the range from 40 to 125°F (4 to 52°C), unless otherwise agreed to by the contracting parties.

7.1.7 *Developer Application:*

7.1.7.1 *Dry Developer*—Immediately after the excess penetrant has been removed from the part, and the surface has dried, the developer is applied in accordance with the manufacturer's instructions to assure complete coverage with a thin, even film of developer. The application of excessive developer should be avoided, since it is possible for a thick coating of developer to mask indications.

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 7.1.7.6.

7.1.7.2 *Aqueous Developers*—Apply by spraying, flowing, or immersing the area being examined prior to drying. Drain excess developer from the area to eliminate pooling of developer that can mask indications. Dry the developer using hot air blast, hot air recirculating oven, infrared heater, or by exposure to ambient temperature. The dried developer appears as a translucent or white coating on the part. Prepare and maintain aqueous developer in accordance with the manufacturer's instructions and apply in such a manner as to assure complete, even coverage. (**Warning—**Atomized spraying of aqueous developers is not recommended, since a spotty film may result.)

7.1.7.3 *Nonaqueous, Wet Developers*—Apply to the area being examined by spraying after the excess penetrant has been removed and the part has been dried. Spray areas so as to assure complete coverage with a thin, even film of developer. This type of developer carrier fluid evaporates very rapidly at normal room temperature and does not require the use of a dryer. It should be used, however, with proper ventilation. (**Warning—**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.) (**Warning—**Dipping or flooding parts being examined with nonaqueous developers is prohibited, since it can flush (dissolve) the penetrant from within the discontinuities through its solvent action.)

7.1.7.4 *Liquid Film Developers*—Apply by spraying as recommended by the manufacturer. Spray parts in such a manner as to ensure complete part coverage with a thin, even film of developer.

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

7.1.7.6 *Developing 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 7.1.7.6 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 *UV-A Irradiation*—Examine fluorescent penetrant indications under UV-A radiation in a darkened area. UV-A irradiance shall be measured with a UV-A radiometer on the surface to be examined. A minimum of 1000 µW/cm^2 is recommended. The UV-A source shall have a peak wavelength in the range of 360 to 370 nm. The UV-A irradiance shall be checked daily to assure the required output. Since a drop in line voltage can cause decreased UV-A irradiation with consequent inconsistent performance, a constant voltage transformer shall be used when there is evidence of voltage fluctuation. (**Warning—**Certain high-intensity UV-A sources may emit unacceptable amounts of visible light, which may cause fluorescent indications to disappear. Care should be taken to use only bulbs certified by the supplier to be suitable for such examination purposes.)

NOTE 8—The recommended minimum in 7.1.8.1 is intended for general usage. For critical examinations, higher UV-A irradiance may be required.

7.1.8.2 *LED UV-A Sources*—LED UV-A sources shall meet the requirements of E3022.

(1) UV-A Source Warm-Up—For all UV-A sources except LED UV-A sources, allow source to warm up for a minimum of 10 min prior to its use or the measurement of UV-A irradiation.

(2) LED UV-A sources are at full intensity at power-on and may decrease as the lamp warms up. If UV-A measurement is made at power-on, then a minimum of 1500 µW/cm^2 is recommended.

7.1.8.3 *Visible Ambient Light*—Visible ambient light shall not exceed 2 fc (21.5 lux). The measurement should be made with a visible light meter on the surface being examined.

7.1.8.4 *Visual Adaption*—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 Practice E165/E165M, 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 in accordance with 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 in accordance with Test Method D808, Annex on Methods for Measuring Total Chlorine Content in Combustible Liquid Penetrant (for halogens other than fluorine) and Practice E165/E165M, 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 Practice E165/E165M can be used as an alternate procedure. Alkali metals in the residue are determined by flame photometry or atomic absorption spectrophotometry.

NOTE 9—Some current standards indicate that impurity levels of sulfur and halogens exceeding 1 % of any one suspect element may be considered excessive. However, this high a level may be unacceptable in some cases, so the actual maximum acceptable impurity level must be decided between the supplier and the 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.

8.3 *Reduced Temperature Examination*—Where penetrant examination is performed on parts that must be maintained at reduced 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*—Personnel performing examinations to this standard shall be qualified in accordance with a nationally or internationally recognized NDT personnel qualification practice or standard such as ANSI/ASNT-CP-189, SNT-TC-1A, NAS-410, ISO 9712, or a similar document and certified by the employer or certifying agency, as applicable. The practice or standard used and its applicable revision shall be identified in the contractual agreement between the using parties.

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; solvent-removable process