



Standard Test Method for Visible Penetrant Examination Using Solvent-Removable Process¹

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1. Scope

1.1 This test method² covers procedures for visible 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 test method also provides a reference:

1.2.1 By which a visible penetrant examination method using the 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 visible, 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 test method does not indicate or suggest standards 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 direction of indications considered acceptable, and those considered unacceptable.

1.4 All areas of this test method may be open to agreement between the cognizant engineering organization and the supplier, or specific direction from the cognizant engineering organization.

1.5 *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.* For specific hazard statements, see Notes 9 and 11.

2. Referenced Documents

2.1 ASTM Standards:

D 129 Test Method for Sulfur in Petroleum Products (General Bomb Method)³

D 516 Test Methods for Sulfate Ion in Water⁴

D 808 Test Method for Chlorine in New and Used Petroleum Products (Bomb Method)³

D 1552 Test Method for Sulfur in Petroleum Products (High-Temperature Method)³

E 165 Test Method for Liquid Penetrant Examination⁵

E 433 Reference Photographs for Liquid Penetrant Inspection⁵

E 543 Practice for Agencies Performing Nondestructive Testing⁵

E 1316 Terminology for Nondestructive Examinations⁵

2.2 ASNT Documents:

SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing⁶

ANSI/ASNT-CP-189 Standard for Qualification and Certification of NDT Personnel⁶

2.3 Military Standard:

MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification⁷

2.4 AIA Standard:

NAS 410 Certification and Qualification of Nondestructive Test Personnel⁸

2.5 *DoD Contracts*—Unless otherwise specified, the issues of the documents that are DoD adopted are those listed in the

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² For ASME Boiler and Pressure Vessel Code applications see related Test Method SE-1220 in Section II of that Code.

³ *Annual Book of ASTM Standards*, Vol 05.01.

⁴ *Annual Book of ASTM Standards*, Vol 11.01.

⁵ *Annual Book of ASTM Standards*, Vol 03.03.

⁶ Available from the American Society for Nondestructive Testing, 1711 Arlington Plaza, Columbus, OH 43228-0518.

⁷ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

⁸ Available from the Aerospace Industries Association of America, Inc., 1250 Eye Street, N.W., Washington, DC 20005.

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 test method and the references cited herein, the text of this test method takes precedence.

3. Terminology

3.1 *Definitions*—definitions relating to liquid penetrant examination, which appear in Terminology E 1316, shall apply to the terms used in this test method.

4. Summary of Test Method

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 by wiping and the surface is dried. If an aqueous developer is to be employed, the developer is applied prior to the drying step. A developer is then applied, drawing the entrapped penetrant out of the discontinuity, staining the developer. The test surface is then examined visually to determine the presence or absence of indications.

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), 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 test method is intended primarily for portability and for localized areas of examination, utilizing minimal equipment. Surface roughness may be a limiting factor. If so, an alternate process, such as water-wash visible or post-emulsified penetrant should be considered when grinding or machining is not practical.

6. Reagents and Materials

6.1 *Visible, Solvent-Removable Liquid Penetrant Examination Materials*, (see Note 1) consist of a family of applicable visible penetrant, solvent remover, as recommended by the manufacturer, and are classified as Type II Visible, Method C—Solvent-Removable. Intermixing of materials from various manufacturers is not recommended.

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

NOTE 2—**Caution:** While approved penetrant materials will not adversely affect common metallic materials, some plastics or rubber may be swollen or stained by certain penetrants.

6.2 *Visible, Solvent-Removable Penetrants* are designed so that excess surface penetrant can be removed by wiping with dry, clean, lint-free material, and repeating the operation until most of the penetrant has 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 should be taken to avoid the use of excess solvent. Flushing the surface

with solvent to remove the excess penetrant is prohibited. Visible penetrant examination makes use of a penetrant that is visible under normal lighting conditions. The penetrant is usually red in color so that the indications produce a definite contrast with the white background of the developer. Visible penetrant indications must be viewed under adequate white light (see 7.1.8.1).

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

6.4 *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. Nonaqueous, wet developers and aqueous developers are the most commonly used developers in the visible, solvent-removable penetrant process. Liquid film developers also are used for special applications.

6.4.1 *Nonaqueous, Wet Developers* are 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 7.1.7.1(a)).

NOTE 3—**Caution:** This type of developer is intended for application by spray only.

6.4.2 *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 manufacturer's recommendations (see 7.1.7.1(b)).

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 surface of the part. Certain types of film developer will fix indications and may be stripped from the surface and retained for record purposes (see 7.1.7.1(c)).

7. Procedure

7.1 The following general procedure applies to the solvent-removable, 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 120°F (4 to 49°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 ceramic 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

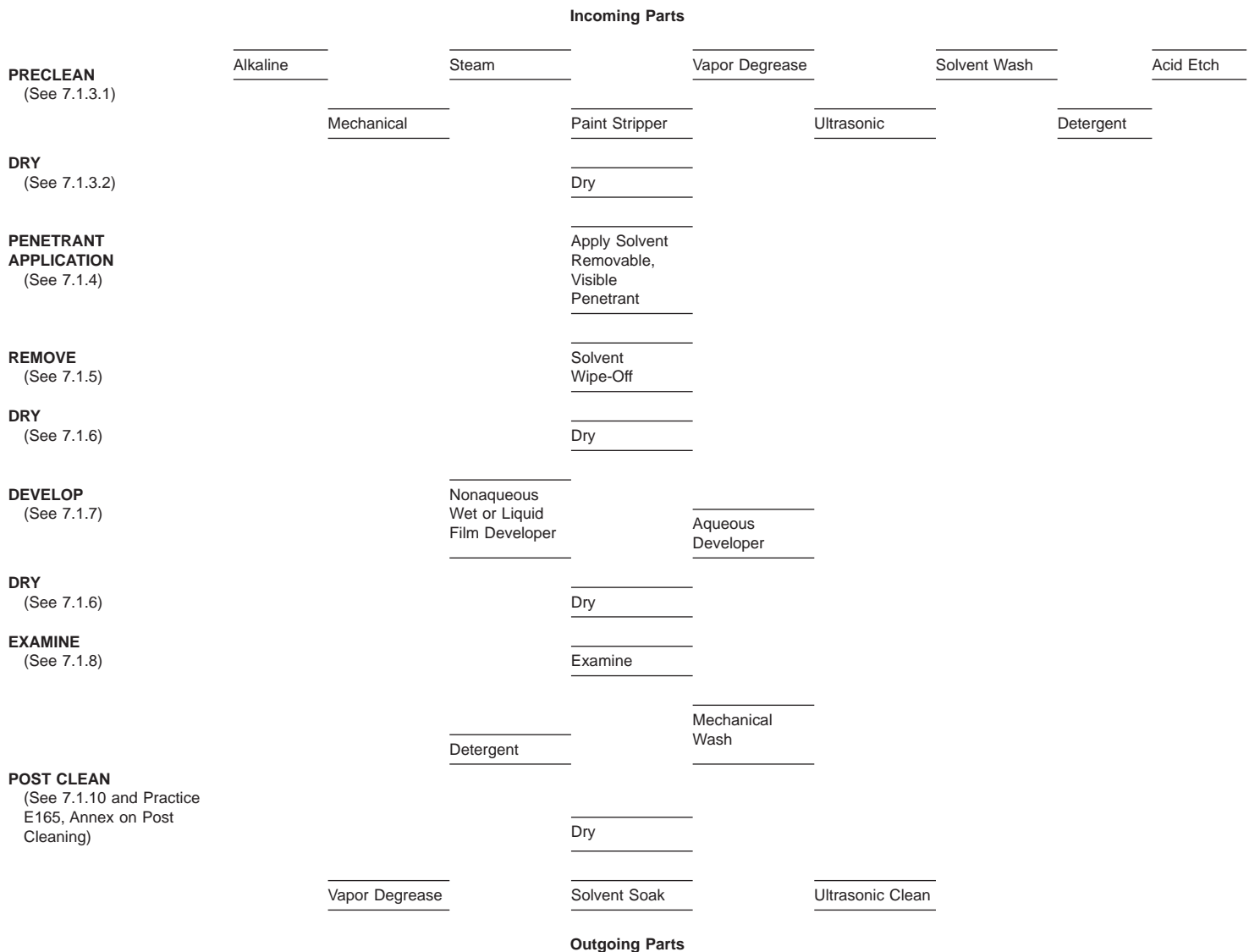


FIG. 1 Solvent-Removable Visible Penetrant Examination General Procedure Flowsheet

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 E 165 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.

NOTE 5—**Caution:** Sand or shot blasting may possibly close indications and extreme care should be used with grinding and machining operations.

NOTE 6—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 that might interfere with the penetrant process. All parts or areas of parts to be inspected must be clean and dry before the penetrant is applied. If only a section of a part, such as a 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 Test Method E 165 for more detailed cleaning methods).

NOTE 7—Caution: Residues from cleaning processes, such as strong alkalis 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 area to be examined 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 area to be examined 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 immersion, brushing, flooding, or spraying. Small parts are 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 could serve as penetrant reservoirs causing severe bleedout problems during examination. Aerosol sprays are also very effective and a convenient portable means of application.

NOTE 8—Caution: Not all penetrant materials are suitable for electrostatic spray applications.

NOTE 9—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 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 discontinuity. Unless otherwise specified, the dwell time shall not exceed the maximum recommended by the manufacturer.

NOTE 10—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 wipes 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 remover solvent and gently wipe the remaining traces to avoid the removing penetrant from discontinuities, taking care to avoid the use of excess solvent. 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 will dry quickly by normal evaporation. Normally, no other drying techniques are necessary, so long as the processing temperature range is within the specified temperature range.

7.1.7 Developer Application:

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

(a) (a) *Nonaqueous, Wet Developers*—Apply to the area being examined by spraying after the excess penetrant has been removed and the area 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.

NOTE 11—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.

NOTE 12—Caution: Dipping or flooding areas being examined with nonaqueous developers is prohibited, since it can flush (dissolve) the penetrant from within the discontinuities through its solvent action.

(a) (b) *Aqueous Developers*—Apply by spraying, flowing, or immersing the area being examined prior to drying (see Note 11). Drain excess developer from the area to eliminate tendencies of pooling of the developer, which can mask indications. Then 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 the aqueous developer in accordance with the manufacturer's instructions and apply in such a manner as to assure complete, even coverage.

NOTE 13—Caution: Atomized spraying of aqueous developers is not

TABLE 1 Recommended Minimum Dwell Times

Material	Form	Type of Discontinuity	Dwell Times, (minutes) ^A	
			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 60° to 125°F (16° 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.

recommended, since a spotty film may result.

(a) (c) *Liquid Film Developers*—Apply by spraying as recommended by the manufacturer. Spray areas so as to ensure complete coverage with a thin, even film of developer.

7.1.7.2 *Developing Time*—The length of time the developer is to remain on the area prior to examination should be not less than 10 min. Developing time begins as soon as the wet (aqueous and nonaqueous) developer coating is dry (that is, the solvent carrier has evaporated to dryness). The maximum permitted developing times are 2 h for aqueous developers and 1 h for nonaqueous developers.

7.1.8 *Examination*—Perform examination of parts after the applicable development time as specified in 7.1.7.2 to allow for proper 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 Light Level*—Visible penetrant indications can be examined in either natural or artificial visible light. Adequate illumination is required to ensure no loss of the sensitivity of the examination. A minimum light intensity at the examination site of 100 fc (1000 lux) is recommended.

7.1.8.2 *Housekeeping*—Keep the examination area free of interfering debris. 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 stain 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 machine wash, vapor degreasing, solvent soak, or ultrasonic cleaning may be employed (see Test Method E 165, Annex on Post Cleaning). In the case of developers, it is recommended that if post cleaning is necessary, it be carried out as promptly as possible after examination so that it does not fix on the part.

NOTE 14—**Caution:** 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 D 129, Test Method D 1552, or Test Method D 129 decomposition followed by Test Methods D 516, Method B (Turbidimetric Method) for sulfur. The residue may also be analyzed in accordance with Test Methods D 808 or E 165, Annex on Methods for Measuring Total Chlorine Content in Combustible Liquid Penetrant Materials (for halogens other than fluorine) and Test Method E 165, 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 E 165 can be used as an alternate procedure. Alkali metals in the residue are determined by flame photometry or atomic absorption spectrophotometry.

NOTE 15—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 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 procedure conforming to the latest 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 E 543 is used to perform the examination, the agency shall meet the requirements of Practice E 543.

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 nondestructive testing; penetrant testing; solvent-removable method; visible liquid

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