Designation: E1220 – 21

Standard Practice for Visible Penetrant Testing Using Solvent-Removable Process[1]

This standard is issued under the fixed designation E1220; 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 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 practice 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 practice 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.

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

1.5 *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.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

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

2. Referenced Documents

2.1 *ASTM Standards:*[3]

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

D516 Test Method for Sulfate Ion in Water

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

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

E165/E165M Practice for Liquid Penetrant Testing for General Industry

E433 Reference Photographs for Liquid Penetrant Inspection

E543 Specification for Agencies Performing Nondestructive Testing

E1316 Terminology for Nondestructive Examinations

[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.

Current edition approved July 1, 2021. Published August 2021. Originally approved in 1987. Last previous edition approved in 2016 as E1220 – 16. DOI: 10.1520/E1220-21.

[2] For ASME Boiler and Pressure Vessel Code applications, see related Test Method SE-1220 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.

2.2 *ASNT Documents:*[4]
SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing
ANSI/ASNT-CP-189 Standard for Qualification and Certification of NDT Personnel
2.3 *Other Standards:*
AMS 2644 Inspection Material, Penetrant[5]
ISO 9712 Nondestructive Testing—Qualification and Certification of NDT Personnel—General Principles[6]
2.4 *AIA Standard:*[7]
NAS410 Certification and Qualification of Nondestructive Test Personnel
2.5 *DoD Contracts*—Unless otherwise specified, the issues 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 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 practice 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 Testing 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. Penetrant materials shall conform to AMS 2644 unless approved by the contract or Level III. Intermixing of materials from various manufacturers is not recommended. (**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 *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 visible background of the developer. Visible penetrant indications must be viewed under adequate visible 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. The developer used shall provide a contrasting white background. 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*)). (**Warning—**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

[4] Available from The American Society for Nondestructive Testing (ASNT), P.O. Box 28518, 1711 Arlingate Lane, Columbus, OH 43228-0518.
[5] Available from SAE International (SAE), 400 Commonwealth Dr., Warrendale, PA 15096, http://www.sae.org.
[6] 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.
[7] Available from the Aerospace Industries Association of America, Inc., 1250 Eye Street, N.W., Washington, DC 20005.

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

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 125 °F (4 to 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 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 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 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 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

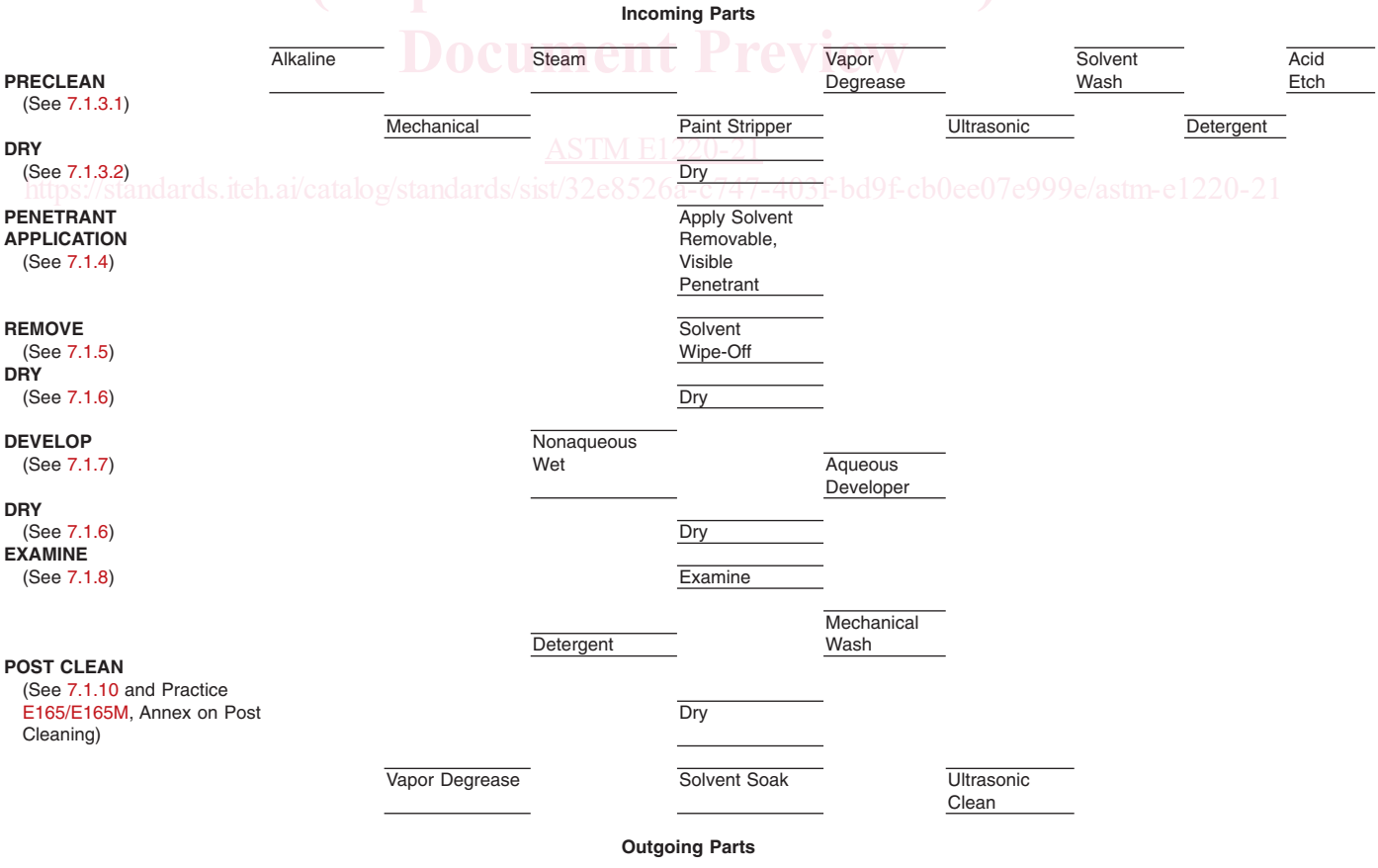

FIG. 1 Solvent-Removable Visible Penetrant Examination General Procedure Flowsheet

penetration. All of these contaminants can prevent the penetrant from entering discontinuities (see Annex on Cleaning of Parts and Materials in Practice E165/E165M for more detailed cleaning methods). (**Warning—**Residues from cleaning processes, such as strong 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. (**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 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 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, 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 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.

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 40° to 125 °F (16° 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). Maximum development time in accordance with 7.1.7.2.

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.

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) 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. (**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.) (**Warning—**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.)

(b) Aqueous Developers—Apply by spraying, flowing, or immersing the area being examined prior to drying. 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