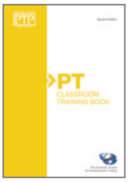

Liquid Penetrant Testing Classroom Training Book second edition

Errata – 1st printing 04/19

The following text correction pertains to the second edition of *Liquid Penetrant Testing Classroom Training Book*. Subsequent printings of the document will incorporate the corrections into the published text.

The attached corrected pages apply to the first printing 04/19. In order to verify the print run of your book, refer to the copyright page. Ebooks are updated as corrections are found.

Page	**Correction**
vi	The correct page numbers for References, Figure Sources, Glossary, and Index should be as follows: References, 85 Figure Sources, 87 Glossary, 89 Index, 93
15	In the final sentence of the second paragraph under Adequate Illumination, the unit of measurement after 1000 in the parentheses should be μW/cm^2.
43	The second sentence should begin "Under UV-A of 3500 μW/cm^2, visible radiation of 440 fc (4735 lx)..."
60	Under Lighting, the second sentence should read, "For fluorescent penetrant indications, the standard lighting is a minimum of 1000 μW/cm^2 UV radiation when measured at 15 in. (38 cm) from the test surface, and a darkened test area of less than 2 fc (20 lx)."
77	Under Twin Nickel-chromium Sensitivity Panels, the final sentence should read, "The panels come in sets having crack depths of 10, 20, 30, and 50 μm."
78	In the last sentence, the unit of measurement should be μW/cm^2.
82	Under Acceptance Criteria, the second sentence in the second bullet item should read "No rounded indications greater than 0.3 in. (0.8 cm) for materials with a design material thickness greater than 0.5 in. (1.3 cm)." Also, the third bullet item should read, "The total area of acceptable rounded indications should not exceed 0.375% of the total area of the test object or weld in any 6 in.^{2} (38.71 cm^2) area, and there should be no more than five indications in any 1 in.^{2} (6.45 cm^2) area.

Catalog #1640
Book printed 04/19
Errata created 12/20

discontinuities. Some PT procedures require that test objects are oven dried at temperatures up to 160 °F (71 °C). As a minimum, all surfaces should be allowed to dry by normal evaporation.

Application of Penetrant

The application of penetrant is performed after the test surface is completely clean and has been properly dried. Almost any technique is allowed for penetrant application, including spraying, brushing, pouring, or dipping. Penetrant should never be allowed to dry completely on the test surface. The test object must be turned or moved to prevent pooling of penetrant during the dwell time. It is important that all test surfaces are completely wetted with a thin coat of penetrant for the entire specified dwell time. In the fluorescent penetrant application, use of a UV radiation source will ensure that all surfaces remain wetted with penetrant and no water break areas occur where the penetrant film separates.

Dwell Time

The penetrant dwell time is the length of time that the penetrant is allowed to wet the surface and enter into discontinuities. The developer dwell time is the length of time that the penetrant is allowed to absorb into the developer before the indications are evaluated.

Removal of Excess Surface Penetrant

The removal of excess surface penetrant is an integral step in the PT process and requires proper lighting and rinse conditions.

Adequate Illumination

Adequate illumination at the rinse station for fluorescent penetrant is no more than 10 fc (100 lx) of white light and greater than 100 $\mu W/cm^2$ of near UV radiation (UV-A) unless stated otherwise in an industry specification. This lighting allows better monitoring of removal of excess fluorescent penetrant and limits possible over rinsing or under rinsing.

The UV radiation background lighting at the rinse station also allows the technician to ensure complete coverage of the test object when using an emulsifier, since the emulsifier is a different color than the penetrant under the UV radiation. The rinse station may be illuminated to the same level as the inspection booth (1000 $\mu W/cm^2$ and less than 2 fc [20 lx]), if desired.

The evaluation of liquid penetrant indications requires proper illumination of the complete testing area. This is usually specified in the PT procedure. For visible dye penetrant, 100 fc (1000 lx) at the test surface is adequate. For fluorescent penetrant tests, the surface should be illuminated with 1000 $\mu W/cm^2$ of UV-A as measured at the test surface, and the white light should be less than 2 fc (20 lx). These lighting levels will meet the requirements of most industrial specifications. However, verification of the proper illumination requirement should be given in the standard procedure or technique being used.

Personnel in the testing area should not wear white clothing, which reflects large amounts of visible light when exposed to UV radiation.

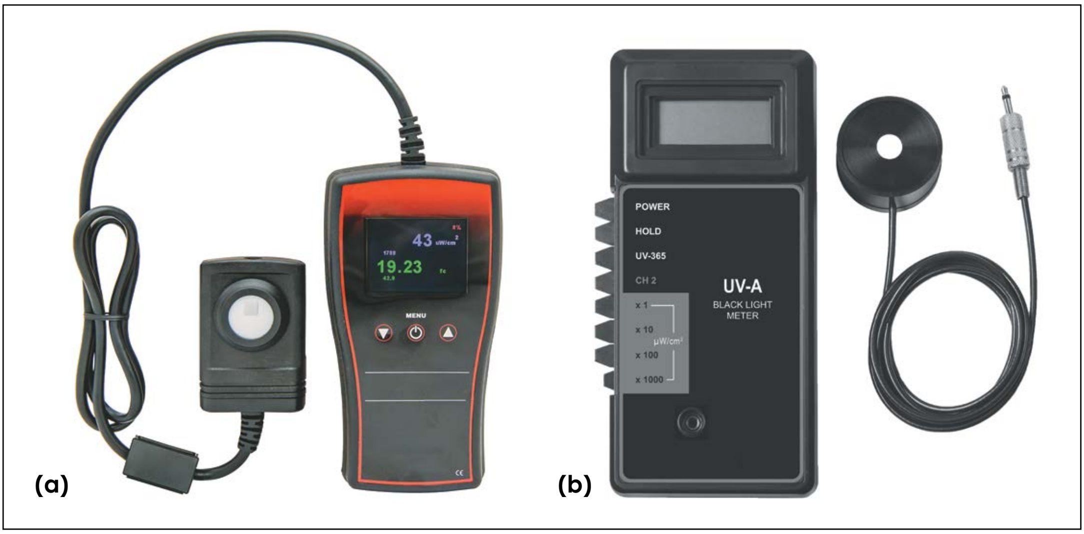

Figure 16. Photoelectric instruments for measurement of UV radiation intensity: (a) dual wavelength radiometer/photometer; and (b) UV meter.

The window lens of the visible radiation (white light) sensor must not fluoresce. Under UV-A of 3500 µW/cm^2, visible radiation of 440 fc (4735 lx) has been reported instead of 1.2 fc (13 lx) as measured with a photometer with a nonfluorescing sensor window.

As an example, a UV radiation illumination level of approximately 800 to 1000 µW/cm^2 is sufficient to reveal most anomaly indications. This will depend, of course, on the size of the indication and type of liquid penetrant system used. There will be applications where extremely high levels of UV radiation intensity are required.

Light Meters

White light and UV radiation are measured with different sensors and in different units of measurement. A standard white light sensor measures in footcandles or lux, and the UV radiation sensor measures in microwatts per centimeter squared (µW/cm^2). Both meter and digital type instruments are available, as shown in Figure 16.

Materials For Liquid Penetrant Testing

The materials used in PT include penetrants, emulsifiers, removers or cleaners, and developers. Penetrants, emulsifiers, removers, and cleaners are furnished in liquid form. Developers are furnished in powder form. The powders may be used in the dry state, or are mixed with a suitable liquid (usually water) before use. Most penetrants, cleaners, and developers are available in pressurized spray cans, as well as in bulk. Concentrations, usage, and maintenance are in accordance with the manufacturer's directions. All bulk materials in use require a daily check for contamination.

(177 °C). High-temperature materials require special procedures, special training, and certification of technicians.

Lighting

The standard lighting for viewing and evaluating visible dye penetrant indications is a minimum of 100 fc (1000 lx) of white light at the test surface. For fluorescent penetrant indications, the standard lighting is a minimum of 1000 μW/cm^2 UV radiation when measured at 15 in. (38 cm) from test surface, and a darkened test area of less than 2 fc (20 lx). The standard lighting in a fluorescent rinse or penetrant removal area is less than 10 fc (100 lx) and greater than 100 μW/cm^2.

Effects of Metal-Smearing Operations

Operations such as power wire brushing or sand blasting can smear metal and close the surface opening of discontinuities (Figure 11). If these operations have been performed on a test object, the surface must be etched to remove the smeared metal. Samples of the visual appearance of smeared metal should be available or used in technician training.

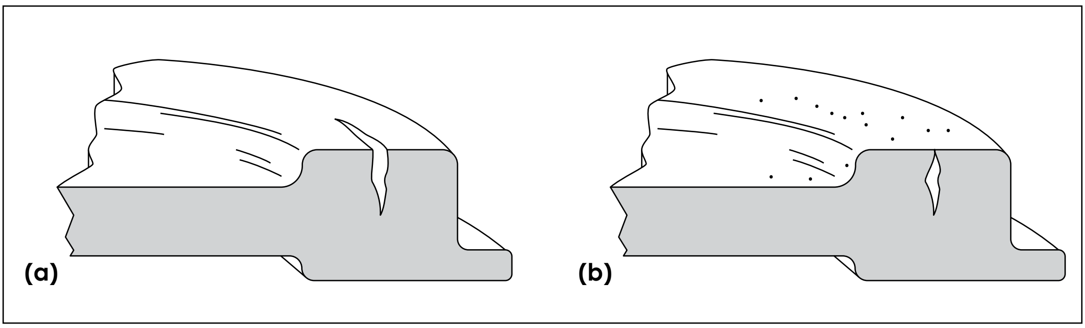

Figure 11. The effect of mechanical cleaning operations on discontinuities: (a) before mechanical cleaning; (b) after mechanical cleaning.

Sequence

In-process tests are sometimes used for the root layer of welds, or before final machining. Final PT is performed on a test object in the final machined and heat-treated condition after proper precleaning.

Test Object Preparation

The test object must be processed through preparation, such as etching, precleaning, and drying, as efficiently as possible. All parts should be properly cleaned and dried prior to penetrant processing.

Factors Affecting Indications

Factors that affect indications include the penetrant used, prior processing, and surface condition of the part.

Penetrant Used

The choice of penetrant depends on the sensitivity requirements, location, availability of UV radiation, water, power, and test requirements.

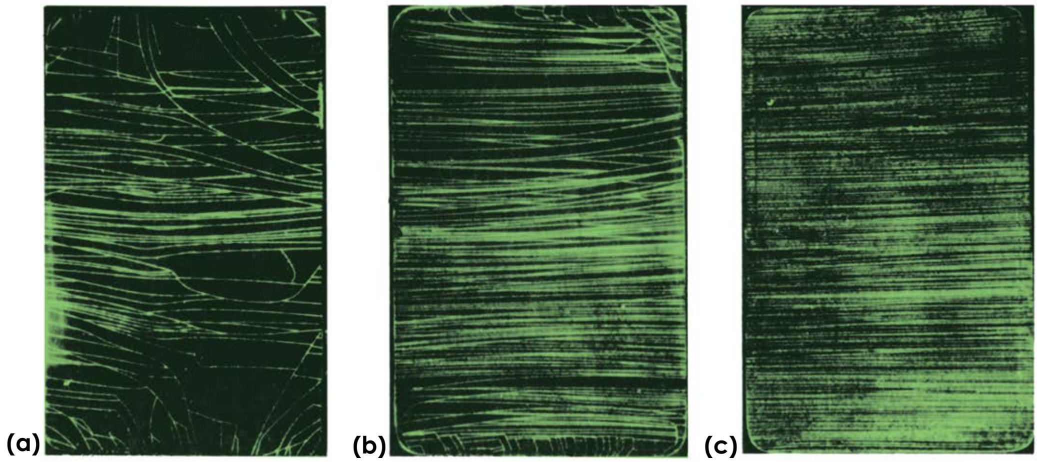

Figure 3. Fluorescent indications of stress cracks in chrome-plated nickel test panels: (a) coarse cracks; (b) medium cracks; and (c) fine cracks.

grades are coarse, medium, and fine, providing low, medium, and high sensitivity levels (see Figure 3).

Preparation for Use

Panel surfaces are scrubbed using moderate pressure and a cloth dampened with emulsifier or concentrated soap solution, followed with a thorough rinse using a water spray. After rinsing, the panel is oven dried at an approved temperature for 3 to 5 min to drive off moisture remaining in cracks. The panel is then dipped in acetone and agitated for approximately 1 min, removed, and again oven dried at an approved temperature for approximately 5 min.

Usage

A line is usually drawn along the centerline (length) of the panel using a wax pencil or narrow vinyl tape. This forms two test areas and permits the side-by-side application and comparison of penetrant materials without cross-contamination.

Twin Nickel-chromium Sensitivity Panels

A set of two nickel-chromium (NiCr) panels, each measuring 3.9 × 1.4 in. (10 × 3.5 cm) is sheared from the same stock. This allows for matching crack patterns. With a matched set of panels, a simultaneous comparison of two penetrant materials can be achieved. The panels come in sets having crack depths of 10, 20, 30, and 50 µm.

Stainless Steel Test Panels

Stainless steel test panels or plates are used in testing the washability of fluorescent penetrants and visible dye penetrants. The panels are prepared from annealed type 301 or 302 stainless steel and measure 2 × 4 in. (5 × 10 cm) or larger. Each is sandblasted on one side with 80 mesh average size grit, at 60 psi (414 kPa), with the gun held approximately

18 in. (46 cm) from the surface. Sandblasting continues until a uniform matte surface is obtained. It is the sandblasted surface that is used in performing tests.

Preparation for Use

Before use, the panels are cleaned by degreasing, heated to 160 °F (71 °C), and then allowed to cool to room temperature in a dry area.

Low Cycle Fatigue Blocks

Titanium or nickel-chromium-iron (NiCrFe) plates are commonly used to manufacture standards with low cycle fatigue (LCF) block cracks in various size ranges. The cracks are started from electrical discharge machined notches or spot welds, which are later ground away after the starter cracks are grown. Tensile stressing or reverse bending of the plates achieves additional crack length extension. Titanium or nickel-chromium-iron plates are commonly sold in a set of three plates, with a total of 18 possible cracks in the set.

LCF blocks are used like other known discontinuity standards, except that the total number of detected cracks per inspection of the plate set is recorded and monitored in a running summary per procedure supplied with the plates. When fewer cracks are detected, the technician is warned that something has shifted in the process capability, or that the cracks have been improperly cleaned.

LCF blocks are cleaned and stored in acetone or equivalent solvent, or in a foam form made for them, as long as they are cleaned with alcohol or acetone before and after each use. LCF blocks can also be returned to the manufacturer for extensive cleaning, if necessary.

Liquid Penetrant Material Tests

The in-service quality of the materials used in PT is determined by a check of sensitivity, water content, contamination, and washability. The tendency toward fading of the penetrant dyes is also checked by a simple comparison test. The tests described as follows are typical of those performed on used or questionable penetrants. These tests should be performed by qualified laboratory technicians.

Sensitivity Comparison Test

When performing a sensitivity comparison test, the penetrant is applied to one-half of the reference block, and the reference or control penetrant is applied to the remaining half. The processing used, including dwell time, emulsification or removal, and developing, is recommended by the penetrant manufacturer.

The indications are then visually compared under the appropriate lighting (normal or white light for visible dye penetrant indications and UV radiation for fluorescent indications). If a noticeable difference exists in the sensitivity or intensity of indications (as determined by visual observation), the penetrant is discarded. Likewise, if the penetrant shows evidence of contamination from dirt, it is discarded.

For the visual testing (VT) of fluorescent indications, the UV radiation source must have an intensity of at least 1000 $\mu W/cm^2$ at the test surface.

ASTM E165

ASTM E165, Standard Practice for Liquid Penetrant Examination for General Industry, covers procedures for penetrant examination of nonporous, metallic materials, ferrous and nonferrous metals, and nonmetallic materials such as nonporous ceramics, as well as certain nonporous plastics and glass. *ASTM E165* is referenced within *ASTM E1417* for the development of detailed requirements.

ASME Boiler and Pressure Vessel Code, Section V, Article 6

The *ASME Boiler and Pressure Vessel Code* is an international code that meets the criteria for and is an American National Standard. Section V outlines the requirements for nondestructive examination. This section is divided further into articles, each of which outlines both general requirements and specific requirements for various nondestructive examination methods.

Acceptance Criteria

Examples of typical liquid penetrant acceptance criteria are as follows (sizes will vary depending on test object application).

- No linear indications allowed. A linear indication is three or more times as long as it is wide. Some specifications specify that all indications less than 0.06 in. (0.15 cm) be evaluated as rounded indications. Some specifications specify that all indications 0.02 in. (0.05 cm) and smaller be disregarded.
- No rounded indications greater than 0.03 in. (0.08 cm) for materials up to 0.25 in. (0.6 cm) design material thickness, and no rounded indications greater than 0.09 in. (0.23 cm) for materials greater than 0.25 to 0.5 in. (0.6 to 1.3 cm) design material thickness. No rounded indications greater than 0.3 in. (0.8 cm) for materials with a design material thickness greater than 0.5 in. (1.3 cm).
- The total area of acceptable rounded indications should not exceed 0.375% of the total area of the test object or weld in any 6 in.^{2} (38.71 cm^2) area, and there should be no more than five indications in any 1 in.^{2} (6.45 cm^2) area.
- Indications separated by less than the length or diameter of the largest indication should be considered a single indication measured from the extremities of the two indications.

Basic Methods of Instruction

Each facility should evaluate the methods of instruction and classes that are required for its PT trainees, Level I, Level II, and Level III technicians, and other personnel involved with the penetrant process. Training methods may include formal classroom lectures, video presentations, informal demonstrations, and hands-on processing of test objects.