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Non-Destructive Testing Procedure for Liquid Penetrant Testing (PT) of Welds

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1. Scope

This procedure outlines the requirements for performing Liquid Penetrant Testing (PT) on welds to detect surface-breaking discontinuities in accordance with **ASTM E165/E165M-23**. It applies to ferromagnetic and non-ferromagnetic weldments in materials such as steel, stainless steel, aluminum, and other non-porous metals.

The procedure covers visible dye and fluorescent penetrant methods using solvent-removable, water-washable, or post-emulsifiable techniques (Type I and Type II, Methods A, B, C, and D).

2. References

- ASTM E165/E165M-23: Standard Practice for Liquid Penetrant Examination
- ASTM E1417/E1417M-21: Standard Practice for Liquid Penetrant Testing (if additional specificity is needed)
- ASTM E709-21: Standard Guide for Magnetic Particle Testing (for reference, if combined inspection is required)
- ASNT SNT-TC-1A (2020): Recommended Practice for Personnel Qualification and Certification
- ASME BPVC Section V (2023): Non-Destructive Examination (if applicable)
- ISO 3452-1:2021: Non-Destructive Testing – Penetrant Testing – General Principles
- Manufacturer's Material Safety Data Sheets (MSDS) for PT chemicals

3. Personnel Qualification

- Certification: Personnel performing PT shall be certified to at least ASNT Level II per SNT-TC-1A or equivalent (e.g., ISO 9712). A Level III shall approve the procedure and oversee implementation.
- Training: Personnel must be trained in PT methods, weld imperfection types (e.g., cracks, porosity, lack of fusion), and safety handling of chemicals.
- Vision Requirements: Personnel shall pass a Jaeger J-2 eye test (or equivalent) for near vision and a color perception test annually, per ASTM E165, Section 7.1.

4. Responsibilities

- Level III: Develops and approves the procedure, qualifies personnel, and ensures compliance with ASTM E165.
- Level II: Performs PT, evaluates indications, and prepares reports.
- Level I: Assists Level II under direct supervision, performing tasks like cleaning or penetrant application.

5. Materials and Equipment

5.1 Penetrant Materials

- Type:
  - Type I (Fluorescent Dye) or Type II (Visible Dye), as specified by the project.
  - Sensitivity: Level 2, 3, or 4 for fluorescent penetrants (per ASTM E165, Annex A1).
- Method:
  - Method A (Water-Washable)
  - Method B (Post-Emulsifiable, Lipophilic)
  - Method C (Solvent-Removable)
  - Method D (Post-Emulsifiable, Hydrophilic)
- Approved Materials: Use penetrants, emulsifiers, and developers listed in QPL-AMS-2644 (Qualified Products List) or approved by the Level III. Examples: Magnaflux ZL-60D (Type I, Method B), Spotcheck SKL-SP2 (Type II, Method C).

5.2 Cleaning Materials

- Solvent cleaners (e.g., Magnaflux SKC-S), water with detergents (pH 6-8), or abrasive methods (e.g., wire brushing, grinding) as permitted.
- Lint-free cloths, brushes, and compressed air for cleaning.

5.3 Equipment

- Lighting:
  - For Type I: UV-A light source (365 nm wavelength, intensity ≥ 1000 μW/cm² at 15 inches, per ASTM E165, Section 7.3). Use a calibrated UV-A meter (e.g., Spectroline DSE-2000).
  - For Type II: White light source (minimum 100 fc or 1000 lx at the surface).
- Ambient Light Control: For fluorescent PT, ambient white light shall not exceed 2 fc (20 lx) at the inspection surface.
- Timers: To monitor dwell and development times.
- Thermometers: To verify surface and material temperatures (40°F to 125°F or 5°C to 52°C).
- Inspection Tools: Magnifying glass (2x-5x), rulers, and discontinuity gauges for sizing indications.

5.4 Calibration

- Verify UV-A and white light meters are calibrated per manufacturer's instructions (at least annually).
- Check penetrant material sensitivity using a known defect standard (e.g., TAM panel or cracked block) before use, per ASTM E165, Annex A1.

6. Safety

- Follow MSDS for all PT chemicals. Wear PPE (gloves, goggles, masks) to avoid skin/eye contact or inhalation.
- Ensure adequate ventilation when using solvents or aerosols.
- UV-A light exposure: Avoid direct eye exposure; use UV-protective glasses.
- Dispose of chemicals per local environmental regulations.

7. Surface Preparation

- Pre-Cleaning: Remove all surface contaminants (e.g., oil, grease, paint, rust, scale) from the weld and adjacent areas (at least 1 inch or 25 mm around the weld) using solvent cleaners, water washing, or mechanical methods (e.g., wire brushing, grinding).
- Surface Condition: Ensure the weld surface is smooth, free of slag, spatter, or irregularities that could mask indications. Grinding is permitted but must not smear or peen defects closed.
- Drying: Dry the surface completely using lint-free cloths or forced air (temperature < 125°F or 52°C). Minimum drying time: 5 minutes or until visually dry.
- Verification: Inspect the surface visually to confirm cleanliness before applying

penetrant.

8. Penetrant Application

- Temperature Control: Ensure the test surface and penetrant are within 40°F to 125°F (5°C to 52°C). For temperatures outside this range, qualify the procedure per ASTM E165, Section 6.3.
- Application Method:
  - Brush, Spray, or Dip: Apply penetrant evenly to cover the weld and adjacent areas. Avoid pooling or excessive application.
  - Coverage: Ensure all weld surfaces, including toes and heat-affected zones (HAZ), are fully coated.
- Dwell Time: Allow penetrant to penetrate for 5-30 minutes (per manufacturer's instructions and material type). Typical dwell times:
  - Steel welds: 10-20 minutes
  - Aluminum welds: 5-15 minutes
  - Adjust based on defect type (e.g., tight cracks may require longer dwell).

9. Penetrant Removal

9.1 Method A (Water-Washable)

- Use low-pressure water spray (≤ 40 psi) at a 45° angle, maintaining a distance of 6-12 inches.
- Wash until no visible penetrant remains, avoiding over-washing (check under UV-A for Type I).
- Dry with lint-free cloths or forced air (temperature < 125°F).

9.2 Method B (Post-Emulsifiable, Lipophilic)

- Apply lipophilic emulsifier by dipping or brushing (avoid spraying).
- Emulsification time: 30 seconds to 2 minutes (per manufacturer's instructions).
- Rinse with water spray as in Method A.
- Dry as above.

9.3 Method C (Solvent-Removable)

- Wipe with lint-free cloths lightly moistened with solvent cleaner (e.g., SKC-S).
- Use a clean, dry cloth for final wiping to remove residual penetrant.
- Verify cleanliness under UV-A (Type I) or white light (Type II).

9.4 Method D (Post-Emulsifiable, Hydrophilic)

- Pre-rinse with water spray to remove excess penetrant.
- Apply hydrophilic emulsifier (diluted per manufacturer's instructions) by dipping or spraying.
- Emulsification time: 30 seconds to 3 minutes.
- Rinse and dry as in Method A.

10. Developer Application

- Type: Use non-aqueous wet developer (e.g., Magnaflux ZP-5B) for Types I and II, unless otherwise specified. Dry powder or aqueous developers may be used if qualified.
- Application:
  - Shake non-aqueous developer thoroughly.
  - Spray a thin, uniform layer from 8-12 inches away.
  - Ensure even coverage without pooling or masking indications.
- Development Time: 10-60 minutes (typically 10-30 minutes). Begin inspection after 10 minutes but before 60 minutes, per ASTM E165, Section 7.5.
- Temperature: Maintain surface within 40°F to 125°F during development.

11. Inspection

- Lighting Conditions:
  - Type I (Fluorescent): Inspect under UV-A light (≥ 1000 μW/cm²) in a darkened area (< 2 fc ambient light). Allow 1-2 minutes for eye adaptation.
  - Type II (Visible): Inspect under white light (≥ 100 fc or 1000 lx).
- Evaluation:
  - Identify indications as linear (e.g., cracks, lack of fusion) or rounded (e.g., porosity).
  - Measure indications using a ruler or gauge for length and width.
  - Compare against acceptance criteria (e.g., ASME Section VIII, AWS D1.1, or project specifications).
  - Record relevant indications (size, type, location) with sketches or photographs.
- False Indications: Differentiate between relevant (defect-related) and non-relevant indications (e.g., surface scratches, penetrant bleed from edges). Re-clean and re-test if needed.

12. Acceptance Criteria

- General: Unless specified by the referencing code (e.g., ASME, AWS), indications are evaluated as follows:
  - Linear indications > 1/16 inch (1.6 mm) are rejectable.
  - Rounded indications > 3/16 inch (4.8 mm) or clusters are rejectable.
  - Four or more rounded indications in a 1-inch² area are rejectable.
- Project-Specific: Refer to the applicable code (e.g., ASME BPVC Section VIII, AWS D1.1) for weld imperfection tolerances. If none specified, consult the Level III or client.

13. Post-Cleaning

- Remove all developer and residual penetrant using solvent cleaners or water washing.
- Ensure the weld surface is clean and free of PT materials to prevent corrosion or interference with subsequent processes (e.g., coating, welding).

14. Documentation and Reporting

- Report Content:
    - Procedure and revision number
    - Date, location, and inspector's name/certification
    - Weld identification (e.g., weld number, drawing reference)
    - PT method, type, materials, and equipment used
    - Surface preparation and environmental conditions
    - Indications observed (type, size, location, acceptance/rejection status)
    - Sketches or photos of rejectable indications
    - Signature of Level II and approval by Level III (if required)
- Retention: Maintain records for at least 5 years or per project requirements.
- Sample Report Template: Available in ASTM E165, Annex A2, or customize per client needs.

15. Quality Control

- Material Checks: Verify penetrant sensitivity using a TAM panel or cracked block daily before testing.
- Light Intensity: Measure UV-A and white light intensity at the start of each shift using calibrated meters.
- Procedure Qualification: For non-standard conditions (e.g., low temperatures), qualify the procedure per ASTM E165, Section 6.3, using a known defect standard.
- Audits: Conduct periodic Level III audits to ensure compliance with this procedure.

16. Limitations

- PT detects only surface-breaking discontinuities.
- Not suitable for porous materials or rough surfaces that retain penetrant.
- Environmental factors (e.g., temperature, contamination) can affect results.
- Fluorescent PT requires darkened conditions and UV safety precautions.

17. Notes

- For critical welds, consider supplementary NDT (e.g., MT or UT) per ASTM E709 or ASTM E164.
- If combining with other methods, ensure PT is performed first to avoid contamination.
- Tailor dwell times and acceptance criteria to specific materials (e.g., aluminum requires shorter dwell due to higher surface tension).
- For high-sensitivity applications (e.g., aerospace), use Level 3 or 4 fluorescent penetrants and qualify per ASTM E1417.

18. Approval

- Prepared by: Ravi Kumar Thammana, ASNT Level III, Trinity NDT WeldSolutions Pvt. Ltd.

- Approved by: [Client/Level III Name], Date: _____

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