# Liquid Penetrant Testing

# Liquid Penetrant Testing

**Overview of Liquid Penetrant Testing (PT):**

- What is PT?
- How is PT Performed?
- PT Processes
- Advantages/Disadvantages
- Safety Precautions
- Certification Requirements

**Definition:**

An NDT method that is used to reveal surface breaking flaws through bleed out of a colored or fluorescent dye from the flaw.

- One of the oldest and most widely used NDT methods
- Can be used on metals and nonmetals, including glass, rubber, plastics, ceramics, etc.

# Liquid Penetrant Testing

**PT provides a means of:**

- Obtaining a visual image of a discontinuity on the surface of the specimen under examination
- Disclosing the nature of the discontinuity without impairing the material (presence of cracks, porosity, etc.)
- Separating acceptable and unacceptable parts in accordance with predetermined standards (the standards are included as “acceptance criteria” within a test procedure)

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**Types of Indications**

- False indications – due to inadequate removal of penetrant during rinse process or contamination from work area or hands – MUST RETEST
- Nonrelevant indications – caused by actual surface discontinuities that are present by design (raised lettering to identify part, etc.)
- Relevant indications – true, unintended, discontinuities that must be interpreted and evaluated

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**How Does PT Work?**

- **Based upon *capillarity* or *capillary action***
  - The tendency of liquids to penetrate or migrate into small openings, such as cracks, pits, or fissures
- Capillarity depends on forces of cohesion, adhesion, surface tension, and viscosity
  - Cohesion – holds like molecules together
    - permits water to rise in a straw
  - Adhesion – causes two different substances to join
    - permits water to spread out over glass

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**More Definitions**

- Surface tension – enables a liquid surface to behave like a thin elastic membrane
  - why small bugs can stand on water
  - why water droplets are spherical
- Viscosity – resistance of a substance to flow
  - honey is very viscous, alcohol is not
- Liquid penetrants tend to have low surface tension (do not bead up) and high capillarity

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**History of PT**

- Used on glazed pottery to check for cracks
- Railroad industry
  - "oil and whiting" method
  - Later largely replaced by magnetic particle inspection
- Magnaflux in Chicago and Switzer in Cleveland performed early research in PT
  - Magnaflux introduced Zyglo in 1942 – first use of fluorescent dyes

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**Steps for Performing a PT**

1) Surface Preparation
   - Surface must be free of paint, oil, grease, water, or other contaminants
   - May require etching
2) Penetrant Application
   - Can be done by spraying, brushing, or immersion in a penetrant bath (dip)
   - Penetrant must be allowed to “dwell” for a minimum time period
     - Dwell time gives penetrant time to be drawn into a discontinuity
     - Time specified by penetrant manufacturer or procedure

# Liquid Penetrant Testing

**Steps for Performing a PT Continued**

3) Excess Penetrant Removal
   - Penetrant to be removed from the surface of the part without removing penetrant from discontinuities
4) Developer Application
   - Developer acts as a blotter to draw the penetrant back to the surface of the part so it can be seen
   - Either a dry powder, dip, or spray
   - Also given time to process (usually a minimum of 10 minutes)

# Liquid Penetrant Testing

**Steps for Performing a PT Continued**

5) Inspection
   - Part is visually inspected under appropriate lighting to detect indications of flaws
6) Final Surface Cleaning
   - Required to remove developer and penetrant from the part

# Liquid Penetrant Testing

**Categorization of PT Processes**

- Categorized by type of dye they contain
  - Type 1 – fluorescent
  - Type 2 – visible
  - Can also be dual sensitivity
- Classified by method for removal of excess penetrant
  - Method A – water-washable
  - Method B – post-emulsified, lipophilic (“likes oil”)
  - Method C – solvent-removable
  - Method D – post-emulsified, hydrophilic (“likes water”)

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**Categorization of PT Processes Continued**

- Finally classified on sensitivity of the penetrant
  - Level ½ - Ultra Low
  - Level 1 – Low
  - Level 2 – Medium
  - Level 3 – High
  - Level 4 – Ultra High

**Sensitivity** – the smallest defect that can be detected with a high degree of reliability

# Liquid Penetrant Testing

**Process Selection**

- Depends on sensitivity required (how small are the suspected cracks?)
- Number of articles to be tested (can products be dipped?)
- Surface condition of the part (rough or smooth)
- Configuration of test specimen (overhead?)
- Specific test conditions (availability of water, compressed air, etc.)

# Liquid Penetrant Testing

**Equipment/Materials**

- Pre-Cleaning/Post-Cleaning
  - Pre-cleaning needed for effective PT (part must be dry)
  - Post-cleaning needed to avoid detrimental effect on part when placed in service
  - Rust, scale, or paint may need to be removed, or etching performed
  - Avoid using wire brushes or metal scrapers – they may cover up discontinuities by smearing metal, thus requiring need for etching
- Stationary vs. Portable Test Equipment
- Black Light - Uses filter that passes only certain wavelengths of light that activate the fluorescent material (and block harmful UV radiation)

# Liquid Penetrant Testing

**Advantages of PT as an NDT Method**

- High sensitivity to small surface discontinuities
- Few material limitations
- Large areas and large volumes of parts can be inspected rapidly and at low cost
- Can inspect parts with complex geometric shapes
- Indications produced directly on surface of part for visual representation of flaw
- Portable method
- Relatively inexpensive

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**Disadvantages of PT as an NDT Method**

- Can only detect discontinuities that are open to the surface
- Can only inspect parts with nonporous surfaces
- Must pre-clean/post-clean parts
- Inspector must have direct access to the part surface
- Time-consuming

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**Benefits of PT Over VT**

- Defects are easier to see because flaw indication much larger than flaw itself
  - Threshold of human visual acuity is ~0.00349” from a distance of 12” (for a person with 20/20 vision)
- Produces a flaw indication with a high contrast
  - High contrast means the flaws are more readily visible against the background due to colored or fluorescent dye

# Liquid Penetrant Testing

**Lighting Requirements**

- Visible penetrant
  - Can use natural or artificial light (white light if possible)
  - 100 foot candles at surface of part
- Fluorescent penetrant
  - Usually specifies a UV light intensity of 1000 µW/cm2 at 15” from filter face
  - White light must be less than 2 fc at surface

# Liquid Penetrant Testing

**Probability of Detection**

Abbreviated P.O.D.

- Curves available that indicate POD for specific test methods vs. size of discontinuity (such as crack length)

PT better at detecting:

- Small round defects than small linear defects
- Deeper flaws than shallow flaws

# Liquid Penetrant Testing

**Safety Precautions**

- Flammability
  - Use exhaust fans to disperse vapors
  - Ignition sources must be avoided
- Skin Irritation
  - Wear gloves to protect hands
  - Wear safety glasses to protect eyes from splashing
- UV Light
  - Lamps get hot – be cautious!
  - Report missing or cracked filter on lamps
    - UV rays can cause sunburn and eye damage if filters not used or not functional

# Liquid Penetrant Testing

**Certification Requirements**

- Per ASNT Recommended Practice No. SNT-TC-1A, 2011 edition:

| Certification Level | High School Graduate or Equivalent (hrs) | Two Years of Engineering or Technical School (hrs) | OJT (hours) |
|---|---|---|---|
| I | 4 | 4 | 70 |
| II | 8 | 4 | 140 |
| Totals: | 12 | 8 | 210 |