

## **LABORATORY EXPERIMENT 2**

## **VISUAL AND LIQUID PENETRANT**

**OBJECTIVES:** To investigate visual inspection tools and techniques with an emphasis on the importance of lighting and the natural limitations of the technique. To learn to enhance visual inspection with several liquid penetrant inspection techniques. To learn the proper procedures required by each technique to successfully detect surface breaking flaws in a number of components.

**MATERIALS:** Visible Dye Penetrant Inspection (Type II, Method C)  
Magnaflux SKC-S Cleaner/Remover  
Magnaflux SKL-WP Penetrant  
Magnaflux ZP -9F Non-aqueous wet developer

Postemulsifiable Hydrophilic Fluorescent Penetrant Inspection (Type I, Method D, Level IV)  
Magnaflux ZL-37 Penetrant  
Magnaflux 7R-10B Hydrophilic Emulsifier  
ZP-4B Powder developer

4 Ti or CRES block specimens (FPI)  
4 Plastic process check specimens (FPI)  
4 Quench cracked aluminum blocks (visible dye)  
3 Pistons (visible dye)  
1 Axle drive shaft (visible dye)  
1 Steel plate (visible dye)  
1 Engine casing (visible dye)

**SAFETY:** Eye and Skin Hazard – The penetrant solution is petroleum based and could damage the eye and dry-out the skin. Eye protection must be worn when applying or removing the penetrant. Gloves are not required but avoid getting the penetrant on skin and clothing. The Ultraviolet lights used in this lab are filtered to remove harmful wavelengths. However, the intense ultraviolet light can cause eye media to fluoresce. This condition called ocular fluorescence is temporary but should be avoided by not looking directly at the UV light or its reflection.

**INSTRUCTIONS:** Select one quench cracked aluminum block, one of the other parts specified for visible dye penetrant examination, one FPI block specimens and one plastic process check specimens. Visually examine each of the parts for evidence of cracking. Perform the examinations first with the unaided eye and experiment with different lighting conditions. Then examine the parts using magnification. Make a diagram of each specimen giving the location

and estimated length of any flaws observed visually and/or indications produced by the subsequent penetrant inspections.

Perform a visible dye penetrant inspection using a portable inspection kit (aerosol cans) on the quench cracked aluminum block. Since these samples have fairly large cracks, the dwell time can be reduced to 5 minutes. Next, inspect one of the parts specified for visible dye penetrant inspection and try to correct any processing problems that were encountered with the first inspection. (Note: Never perform a visible dye penetrant inspection on a part that will subsequently be inspected using fluorescent penetrant inspection (FPI). Residual visible dye in a flaw can prevent the formation of a detectible FPI indication.

Perform a fluorescent penetrant inspection on the plastic process check specimen and the Ti or CRES block specimen. Use a Method A (water-washable) penetrant with Level IV sensitivity and a powder developer.

**PROCEDURE:**

The liquid penetrant inspections shall be conducted in general accordance with ASTM E 1417. The general procedure is provided but additional information can be found by consulting the specification,

Visible Dye Penetrant Procedure (Type II, Method C)

1. Specimens should be visually examined for flaws before the application of penetrant.
2. Specimens should be cleaned to remove contaminates that could prevent penetrant from entering discontinuities and thoroughly dried.
3. Apply a thin, even coating of penetrant to the part by spraying.
4. Allow the penetrant to dwell on the surface for 10 minutes or longer.
5. Remove excess surface penetrant by wiping the surface with a dry lint-free cloth. Try to minimize the number of times the surface is wiped as each pass of the cloth could pull penetrant from a flaw.
6. Finish the cleaning by dampening a cloth by spraying with solvent and wiping the surface one final time.
7. Apply a light uniform coating of well agitated, non-aqueous wet developer by spraying. Excess developer will reduce the sensitivity of the inspection; this is the most common error made with liquid penetrants.
8. Inspect the surface as the developer works to pull the penetrant from any surface breaking flaws to produce an indication. Allow the sample to develop for a minimum of 10 minutes.

9. Record the location, size, orientation and other features of interest of any indications produced by the inspection.
10. Clean all specimens by first rinsing off the developer and then ultrasonically cleaning for 15 to 30 minutes.

Postemulsifiable Hydrophilic Fluorescent Penetrant Inspection (Type I, Method D, Level IV)

1. Specimens should be visually examined for flaws before the application of penetrant.
2. Specimens should be cleaned to remove contaminants that could prevent penetrant from entering discontinuities and thoroughly dried.
3. Apply the penetrant by immersing the sample in the solution.
4. Allow the penetrant to dwell on the surface for a minimum of 10 minutes.
5. Remove the majority of the penetrant from the surface with a coarse water spray. The spray gun should be held at least 12 inches from the surface and spray should impact the surface at an angle to avoid forcing water into any flaws.
6. Apply the emulsifier by immersion and mildly agitate the sample in the solution. The maximum contact time of the emulsifier shall be 2 minutes. (Tip: remove the part from the emulsifier and be ready to start washing at or before 2 minutes.
7. Thoroughly wash the sample to remove the emulsifier and remaining surface penetrant using the procedure in step 3.
8. Dry the sample in the hot air recirculating oven.
9. Apply developer by immersing the sample in the dry powder.
10. Inspect the sample under ultraviolet light as the developer works to pull the penetrant from any surface breaking flaws to produce an indication. Allow the sample to develop for a minimum of 10 minutes. While waiting for the sample to develop, check the intensity of the UV light with the digital radiometer. The intensity should be at least  $1000 \text{ mW/cm}^2$  at a distance of 15 inches.
11. Record the location, size, orientation and other features of interest of any indications produced by the inspection.
12. Clean all specimens by first rinsing off the developer and then ultrasonically cleaning for 15 to 30 minutes.

**DISCUSSION:**

If not already covered in the Introduction section of the report, explain how penetrant inspection enhances a visual inspection.

Discuss the capabilities and limitations of the penetrant inspection method (e.g., suitability for surface-breaking and sub-surface flaws, specimens with complex geometry, coatings materials types, etc.)

Compare the Type I (visible), Method C (solvent removable) penetrant process to the Type II (Fluorescent), Method D (hydrophilic postemulsifiable water-washable) penetrant process. Note the particular circumstances that could be considered when choosing to use one types/method over the other.

Discuss why a penetrant with level IV sensitivity was suitable for use in inspecting the Ti or CRES blocks but might not be right for all penetrant inspections (address flaw type and surface condition).

Comment on the results of the samples inspected with the visual dye penetrant. Did the inspection produce equal results on both the sanded and unsanded side of the quench cracked blocks? Based on the results of the inspection of the other component, consider whether the parts might be suitable for use, should be scrapped or whether further testing is required. If further information is needed, indicate what this might be.