Table of Contents

5.4 LIQUID PENETRANT

5.4.1 Introduction

Liquid Penetrant Testing is used to confirm the presence of a crack or flaw. It relies on the ability of a liquid to enter into a discontinuity. Therefore it can only find discontinuities, which are open to the surface of the material. It can be applied to any material provided it is non-porous, and is not adversely affected by the penetrant material.

The basic procedure requires that the material be pre-cleaned to remove all surface contaminants and the application of a liquid (penetrating oil) to the surface being tested. The penetrant will seek out and enter small surface openings. Penetrant is then removed from the test surface by wiping or water rinsing. A drying developer is next applied. The penetrant remaining in the discontinuity bleeds out forming a highly visible, contrasting indication on the test surface.

The characteristics of a good penetrant relate to the ability of the fluid to be drawn into small openings even against gravity. This penetrating ability is affected by many variables including surface tension of the liquid, wetting ability, surface condition, surface contamination, and temperature.

There are two major types of penetrants used: (1) visible dye penetrants, and (2) fluorescent-visible penetrants. Visible dye penetrants are normally red, providing contrast with the applied white developer. Fluorescent penetrants contain dyes, which fluoresce brilliantly when viewed under black light in a darkened area. The ability to see penetrant indications on the test surface relates to the contrast provided between the penetrant and the test surface. Fluorescent penetrants provide better contrast than visible dye penetrants. For this reason, fluorescent penetrants are more accurate than visible dye penetrants. Refer to Figure 5.4.1-1 for a view of a casting with the dye and developer applied to the surface. Refer to Figure 5.4.1-2 for a view of a gusset plate with applied dye penetrant.

Interpretation of the liquid penetrant indication involves determining what condition is present to have caused the indication, evaluating the condition as to its effect and seriousness from the standpoint of usability of the part, and reporting of inspection results accurately and clearly.

Proper interpretation and evaluation of liquid penetrant indications requires knowledge of the types, causes, and appearance of indications, knowledge of the test method and material fabrication process, adequate illumination, good eyesight, and experience.

This testing method is covered in American Society for Testing and Materials (ASTM) E165-95 “Standard Test Method for Liquid Penetrant Examination” and ASTM E1417-99 “Standard Practice for Liquid Penetrant Examination.”

Figure 5.4.1-1: Liquid Penetrant and Developer Applied to a Casting.

Figure 5.4.1-2: Gusset Plate with Applied Dye Penetrant.

5.4.2 Applications

Liquid penetrant tests can be conducted on a wide variety of non-porous materials including metallic and non-metallic, magnetic and non-magnetic, as well as conductive and non-conductive. This method is highly sensitive to small surface discontinuities and produces indications directly on the surface of the component providing a visual representation of the flaw.

The penetrant materials typically come in aerosol form making them very portable and well adapted to field use. This also allows large areas of a component to be tested rapidly even if the component has a complex geometric shape. Powder penetrant materials are also available, but are typically cumbersome in the field.

Finally, penetrant materials and the associated equipment are relatively inexpensive, especially when compared to most other nondestructive evaluation (NDE) methods.

5.4.3 Limitations

Liquid penetrant testing does have several limitations. This method only works on non-porous materials. Also, surface finish and roughness can affect the sensitivity of the test.

It can only detect discontinuities which are open to the surface. Discontinuities filled with contaminants, paint, rust, oxidation, or corrosion products may not be detected. Therefore, pre-cleaning is critical. The process also requires multiple steps of cleaning, applying the dye/fluorescent, cleaning off the dye/fluorescent, applying the developer, and cleaning off the developer after the test is completed. This effort requires the safe handling of chemicals and the proper disposal of saturated cleaning rags and empty aerosol cans.

Finally, the test sensitivity is lowered at reduced temperatures since crack widths are typically reduced and the test medium is less fluid.