

Water-Washable and Post-Emulsified Penetrants

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Although Liquid Penetrant Inspection is recommended for the detection of all types of surface flaws, the selection and use of the penetrant is going to depend on a number of factors. If you are working to any specification, whether military or private, the penetrant selection for your process will be spelled out for you.

Other selection criteria include the surface and configuration of the part to be tested. Also, the size and location of the defect determines the sensitivity level required. Also how critical is the function of the part to be inspected, such as used in rotating or moving components, or subject to excessive heat.

All penetrant materials do not perform the same and are not designed to do so. Magnaflux has developed different formulations to address a variety of inspection applications. For the purpose of this discussion, we will look at both water-washable and post-emulsified penetrants.

Water-Washable Penetrants

Magnaflux water-washable penetrants (Method A) are available as Fluorescent (Type 1) or Visible (Type 2) penetrants and in all sensitivity levels. The water-wash method is popular for several reasons. It is less expensive, the process time is quicker, there are fewer processing steps and timing variables are reduced.

Water washable penetrants work best on rough surface parts, threaded or grooved parts and those with holes and orifices, which may be difficult to remove with the post emulsification method. It is especially suitable for automation, larger parts, leak testing, and use on parts which are incompatible with oil based systems.

Water washable penetrants are removed by manual or automated water spray, manual wipe or air agitated immersion wash. If a manual spray is used the water pressure should not exceed 40 psi; the temperature should be between 50 –100 F using a coarse spray at a minimum distance of 12 inches. Although water washable processing has its advantages, certain specifications will restrict its use because over-washing can occur in shallow discontinuities, which makes rinsing time critical to the process.

Recommended Developers for Water Washable Penetrants

Developers increase the visibility of both the visible and fluorescent penetrants. They draw the penetrant out of the flaws and spread the indication for brighter results. The developer you choose should be able to provide a good uniform contrast, be easy to apply and remove, and work well with the penetrant chosen.

Dry developers, such as ZP-4B is the most effective for fluorescent water washable penetrants. It is the easiest to apply developer. Before using a dry developer, it is important that the part be completely dried after the rinse before applying the dry powder. It can be applied by immersion or by dusting with hand held powder bulbs. In automated systems, developers are applied in a swirl cloud developer station. Magnaflux recommends the use of a dust collector to evacuate the powder from the chamber. A non-aqueous developer such as ZP-9F is a convenient solvent developer for portable fluorescent aerosol penetrant inspections.

Water-soluble developers are not recommended for use with water washable penetrants because it is possible that when used with these penetrants, it will act as an additional emulsifier and wash

the penetrant away. Many specs will prohibit the use of these developers with water washable penetrants.

With visible water-washable penetrants, a *non-aqueous or solvent developer* is recommended because it gives the best contrast to the penetrant.

Advantages to Water Washable Penetrant

- Lower cost (no emulsifier needed)
- Fewer processing steps
- Process time reduced
- Variables associated with PE dwell time eliminated

Disadvantages to Water Washable Penetrant

- Over washing can occur in shallow defects
- Water rinsing time is critical
- Water contamination is susceptible.

Post-Emulsifiable Penetrants

When removal of the penetrant from the defect due to over-washing of the part is a concern, a post emulsifiable penetrant system can be used. These parts are usually smoothed surfaced and perform critical functions which require higher sensitivity to smaller defects. Post emulsifiable penetrants require a separate emulsifier to break the penetrant down and make it water washable. Method C relies on a solvent cleaner to remove the penetrant from the part being inspected. Method B and D penetrants require an additional processing step where a separate emulsification agent is applied to make the excess penetrant more removable with a water wash. Lipophilic emulsification systems are oil-based materials that are supplied in ready-to-use form. Hydrophilic systems are water-based and supplied as a concentrate that must be diluted with water prior to use.

Emulsifiers

Lipophilic emulsifiers like ZE-4B (Method B) were introduced in the late 1950's and work with both a chemical and mechanical action. After the emulsifier has coated the surface of the object, mechanical action starts to remove some of the excess penetrant as the mixture drains from the part. During the emulsification time, the emulsifier diffuses into the remaining penetrant and the resulting mixture is easily removed with a water spray.

Hydrophilic emulsifiers like ZR-10B (Method D) also remove the excess penetrant with mechanical and chemical action but the action is different because no diffusion takes place. Hydrophilic emulsifiers are basically detergents that contain solvents and surfactants. The hydrophilic emulsifier breaks-up the penetrant into small quantities and prevents these pieces from recombining or reattaching to the surface of the part. The mechanical action of the rinse water removes the displaced penetrant from the part and causes fresh remover to contact and lift newly exposed penetrant from the surface.

The hydrophilic post emulsifiable method is more sensitive than the lipophilic post emulsifiable method and has made the latter method virtually obsolete. The major advantage of hydrophilic emulsifiers is that they are less sensitive to variation in the contact and removal time. While emulsification time should be controlled as closely as possible, a variation of one minute or more in the contact time will have little effect on flaw detectability when a hydrophilic emulsifier is used. However, a variation of as little as 15 to 30 seconds can have a significant effect when a lipophilic system is used.

Advantages of the Post- Emulsifiable Penetrant Process

- Higher sensitivity to smaller defects
- Shows wide, shallow defects
- More controlled removal of surface penetrants

Disadvantages of the Post- Emulsifiable Penetrant Process

- Extra processing step
- Emulsification time control is critical
- Penetrant removal is difficult in threaded parts, holes and slots
- Not good on rough surfaces