Material Hazards in Penetrant Testing

The physical health of liquid penetrant testing personnel should not be impaired by performance of liquid penetrant testing. To ensure health and freedom from accidents or injury, test personnel should be aware of job related hazards and safety precautions.

Prolonged breathing of penetrant vapors, emulsifier vapors or solvent remover vapors may cause headaches, nausea or tightness or pain in the chest. To avoid this problem, forced air ventilation exhausting to the outside of the building may be required in addition to constant alertness to breakdown of the system or increased sensitivity of personnel.

General personnel restrictions regarding cleanliness of the work area, wearing of safety shoes or limiting of loads to be lifted manually are applicable to liquid penetrant testing personnel and affect the ability of the operator to perform.

During a test, liquid penetrant materials can have direct, unsafe effects on human operators — for example, topical exposure to chemical solvents. The materials expended in liquid penetrant tests include organic pigments, petroleum distillates, wetting agents, corrosion inhibitors, powders and various cleaning compounds and solvents. As a group, they are not highly dangerous chemicals but they must be used with care. Particular care is required when handling unhealthy or flammable liquids and vapors. Good ventilation must be provided.

Helpful Regulatory Agencies

A number of governmental organizations around the world are involved with promoting and enforcing safety and health in the work place. Others aim at protecting the environment from contamination by industrial materials. In the United States, three such organizations are the American Conference of Governmental Industrial Hygienists (ACGIH), the Environmental Protection Agency (EPA), and the Occupational Health and Safety Administration (OSHA). These and similar agencies are continually examining industrial practices and materials to reduce hazards to personnel and the environment. For example, certain ingredients used formerly in nonaqueous developers and some penetrant aerosols have been required to be replaced. Most notably, these include the elimination of halogenated solvents and hexavalent chromium. This article discusses some chemical hazards to personnel safety and health. Because most filtered particle test fluids consist of particles suspended in light petroleum distillates, the discussion below regarding liquid penetrant fluid materials applies to the filtered particle fluids as well. Environmental concerns with respect to liquid penetrant test effluents are discussed elsewhere in Vol. 2 of the NDT Handbook, third edition.

Topical Exposure to Penetrant Materials

Penetrant test materials are carefully screened for health hazards and are qualified as safe for humans in an industrial operation. When used in accordance with manufacturer’s instructions, no health hazard should be encountered (Fig. 1). Humans vary from person to person and may react differently to liquid penetrant materials, usually with allergic reactions. Allergies usually manifest themselves as dermatitis on the hands or arms. Other forms of allergic reaction are more subtle and need to be evaluated by competent medical personnel. If allergies persist, the operator may be unable to perform penetrant testing routinely.

Practically all liquid materials used in liquid penetrant testing, including penetrant, cleaner and developers, have very good wetting and detergent properties. Most of them exhibit excellent solvent power for fats and oils. If these materials are allowed to remain in contact with body surfaces for extended periods, the natural oils will be dissolved from the skin, causing it to become rough and red and eventually to crack. In this condition, secondary infection can take place, causing severe irritation or dermatitis.

Skin Care. Preventive measures to lessen the likelihood of skin infection should be used to protect personnel who handle liquid penetrant processing materials and test parts that carry these materials on their surfaces. In many instances, synthetic rubber or other impervious gloves are
essential for handling baskets and test parts during liquid penetrant processing. Useful guidelines have been issued by federal agencies.2-4

The operators' hands or any skin surfaces contacted by liquid penetrants or processing materials should be washed thoroughly with soap and water at least twice during each 8 h shift or working period and before eating. This washing (together with impervious gloves where required) is usually enough protection if contact with liquid penetrant processing materials is only occasional.

Where continued or prolonged contact with processing materials is necessary, a protective cream resistant to the test materials should be applied to the skin and renewed, after thorough washing of hands, arms or portions of the body exposed to processing materials, as often as this cream wears off. If the skin reddens, the inflammation can often be relieved by the use of cream or lotion such as lanolin that contains animal fat. Lanolin cannot restore the oil lost from the skin but it can serve as a substitute for the lost skin oil. If loss of oil causes dry skin to crack, these cracks may permit infections to develop from any sources in the environment. Skin damage, or dermatosis, could result from neglect of precautions.

Flammability of Penetrant Materials

Flash point is the temperature to which a material must be raised to create vapors of a type and quantity that produce a combustible or explosive mixture with the air immediately above the surface of the liquid. There are several ways to measure flash points. In general, the technique of measurement involves raising the temperature of the liquid in a predetermined schedule and periodically introducing a flame or other ignition in the atmosphere immediately above the liquid surface. The temperature at which the vapor-and-air mixture first ignites is the flash point.

Just what constitutes a safe flash point depends on the conditions under which a material is used and how it is to be shipped. In the United States, changing regulations of federal or state or local regulations may dictate minimum allowable flash points. Requirements of the most recent regulations should be determined and followed in choice of penetrant processing materials and work locations. Even if materials are used in very small quantities where ventilation is good, care should be taken to insure that harmful vapors do not accumulate. In the case of portable kit-type liquid penetrant test materials (aerosols), the materials are kept in small containers that are completely closed. Though these materials are brought into the open in such small quantities that normal air circulation should dilute their vapors to less dangerous concentrations, care should be exercised to prevent the accumulation of vapors.

Caution: smoking around highly flammable materials must be prohibited.

Some of the materials intended for use in small portable kits may have considerably lower flash points due to the propellant used in the aerosols. While aerosol cans may have penetrant material contents that have flashpoints as low as 5 °C (40 °F), they are commonly propelled by a mixture of butane and propane, and these propellants have flash points far below zero. Consequently, the spray from the aerosol can is highly flammable. When used with the precautions and in the manner prescribed by their manufacturers and in work areas with ensured good ventilation, these materials can be used safely. However, it should always be borne in mind that spray application of flammable liquids reduces the product to the form of a fine mist composed of minute droplets. In this form, atmospheric contamination becomes more acute and the flammability hazard is increased.

Where liquid penetrant materials are used in large open tanks with extensive exposed surface area, the problem is entirely different. The large surface area can foster rapid liberation of vapors. The dipping of test parts or baskets into the liquid can promote evaporation. In addition, the sides of the tank above the liquid surface level act as a barrier that retains the vapors and can permit a high vapor concentration to accumulate.

In the United States, Occupational Safety and Health Administration (OSHA) regulations established the minimum flash point at 93 °C (200 °F) for flammable liquids in large open tanks, used without special precautions. The determination of flash point is required by the Occupational Safety and Health Administration for these materials.

Figure 1. When used in accordance with manufacturer’s instructions, penetrant test materials are qualified as safe for humans in an industrial operation: spray application of portable penetrant onto part.
applications. It has also been required that specified automatic fire protection apparatus must be installed and maintained in operating condition when liquids with flash points below 93 °C (200 °F) are used in open tanks with liquid surface areas larger than 1 m² (10 ft²).

Many plants have their own regulations as to permissible flash points for solvents and similar materials used in open tanks. In cases where such rulings do not exist, the choice is the responsibility of the facility management, under applicable state and federal regulations. As a rough guide, a flash point of 93 °C (200 °F) should be considered as the minimum allowable for liquid penetrant processing materials used in open tanks, unless required special safety precautions can be enforced and suitable safety equipment is made a part of the installation. In the United States, compliance with all applicable Occupational Safety and Health Administration or other federal, state and local regulations is essential.

Precautions for Solvent Removers. Test operators and their management should be aware that most solvent removers present fire and health hazards. Do not use flammable solvents near ignition sources. Use volatile solvents only with ventilation adequate to carry solvent vapors away from closed areas. Before repair by welding after solvent applications, use care to make certain that all volatile material has evaporated from test parts.

Sometimes it is not possible to use solvent cleaners and developers only in open, ventilated areas. When testing must take place inside tanks or other closed areas, inspectors should work with a companion. Within closed tanks, all personnel should be provided with adequate ventilation or with equipment to supply breathing air.

Safety Considerations for Developers. All of the developers procured as dry powders offer, to some extent, the possibility of personnel inhalation of developer dust. The extremely fine particle size of the dry developer makes it likely to become airborne. This product should be applied in a well-ventilated area or within a hood equipped with an exhaust system to reduce inhalation. Nonaqueous wet developer also involves some hazard because of inhalation of the solvent carriers in which the developer particles are suspended. The solvent carriers are normally flammable. Precautions for use of flammable solvents should be observed when using nonaqueous developers.

Material Safety Data Sheets

To keep track of toxic and hazardous chemicals, each employer needs to keep on file a material safety data sheet (MSDS) for each chemical. These are provided by the manufacturer either in printed form, on the manufacturer’s website or both and they are usually easily available at the workplace. The form and content of these sheets are specified by the National Institute for Occupational Safety and Health, and much of the necessary information is provided online in government-sponsored web pages. Personnel working with penetrant inspection should review these data that outline and describe the recommended precautions that should be taken when using the materials.

Other Safety Concerns

Several important components of safety in penetrant testing are not addressed in this brief article.

1. Electrical safety is addressed in codes and standards for fire and electric safety.
2. Care should be taken to avoid exposure to ultraviolet radiation other than UV-A. Personnel using ultraviolet lamps should avoid looking directly into the light source. Eyewear capable of blocking ultraviolet radiation should be worn when conducting fluorescent penetrant inspections. It is also recommended that inspection personnel should wear long-sleeved clothing to minimize exposure.
3. Safety requires good lighting and good housekeeping in work areas. (Maintaining good vision and appropriate ambient lighting is also essential for reliable visual observation of penetrant test indications.)

It is the responsibility of the employer to provide a safe working environment for its personnel. Supervisors need to study and follow applicable laws and guidelines indicated by the federal, state, and local authorities, as well as procedures specific to the employment contract and workplace.

References