WLD 204
Non Destructive Testing I
Penetrant Testing

Welding Technology

Portland Community College

NSF -ATE Project

Advanced Materials Joining for Tomorrow's Manufacturing Workforce

INDEX

This project was supported, in part, by the

National Science Foundation

Opinions expressed are those of the authors
And not necessarily those of the Foundation

LIQUID PENETRANT INSPECTION (PT)

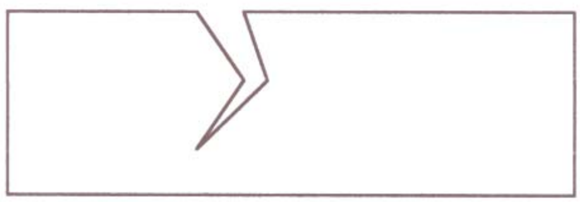
Liquid penetrant inspection is a method of nondestructive testing used to detect discontinuities that are open to the surface. It can be used for the inspection of most materials of a nonporous nature such as steel, stainless steel, aluminum, ceramics, glass, and some plastics.

Method

Examination by liquid penetrant testing is accomplished in five basic steps:

Pre-cleaning. Each item to be inspected must have all contaminants, such as dirt, grease, oil, rust, etc., removed from the surface to be inspected. The cleaning must also remove these contaminants from any possible discontinuity (see 1-1).

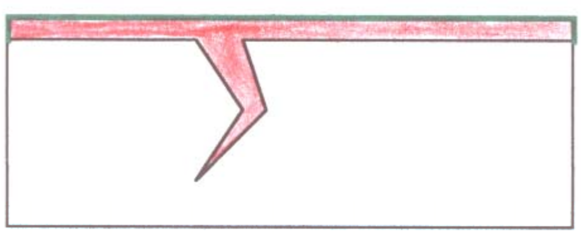
Visible Crack



Cleaned surface

(1-1)

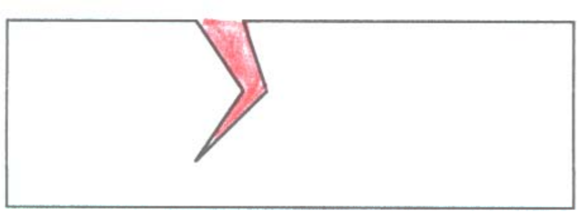
Applying the penetrant. Once the item is cleaned, the penetrating liquid is applied to the surface in an even layer. The penetrant will be colored red for high visibility or will contain a fluorescent dye for viewing under ultraviolet light. The penetrant must remain on the part for a given period of time (dwell time) usually twenty to thirty minutes. The dwell time allows the penetrant to be pulled down into each discontinuity by capillary action (see.1-2).



Penetrant applied

(1-2)

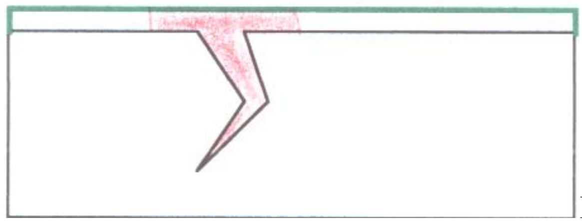
(3) Removing the excess penetrant. After the penetrant has been allowed to sit for the proper dwell time, rapidly remove or wash the penetrant from the surface. Penetrant will be left within the discontinuities (see1-3) do to lack of time for escape.



Excess penetrant removed

(1-3)

Applying the developer. The developer pulls the penetrant from any discontinuity in the item. The developer used with the red penetrant is a suspension of white particles. As the penetrant is pulled into the developer an indication appears (see 1-4).

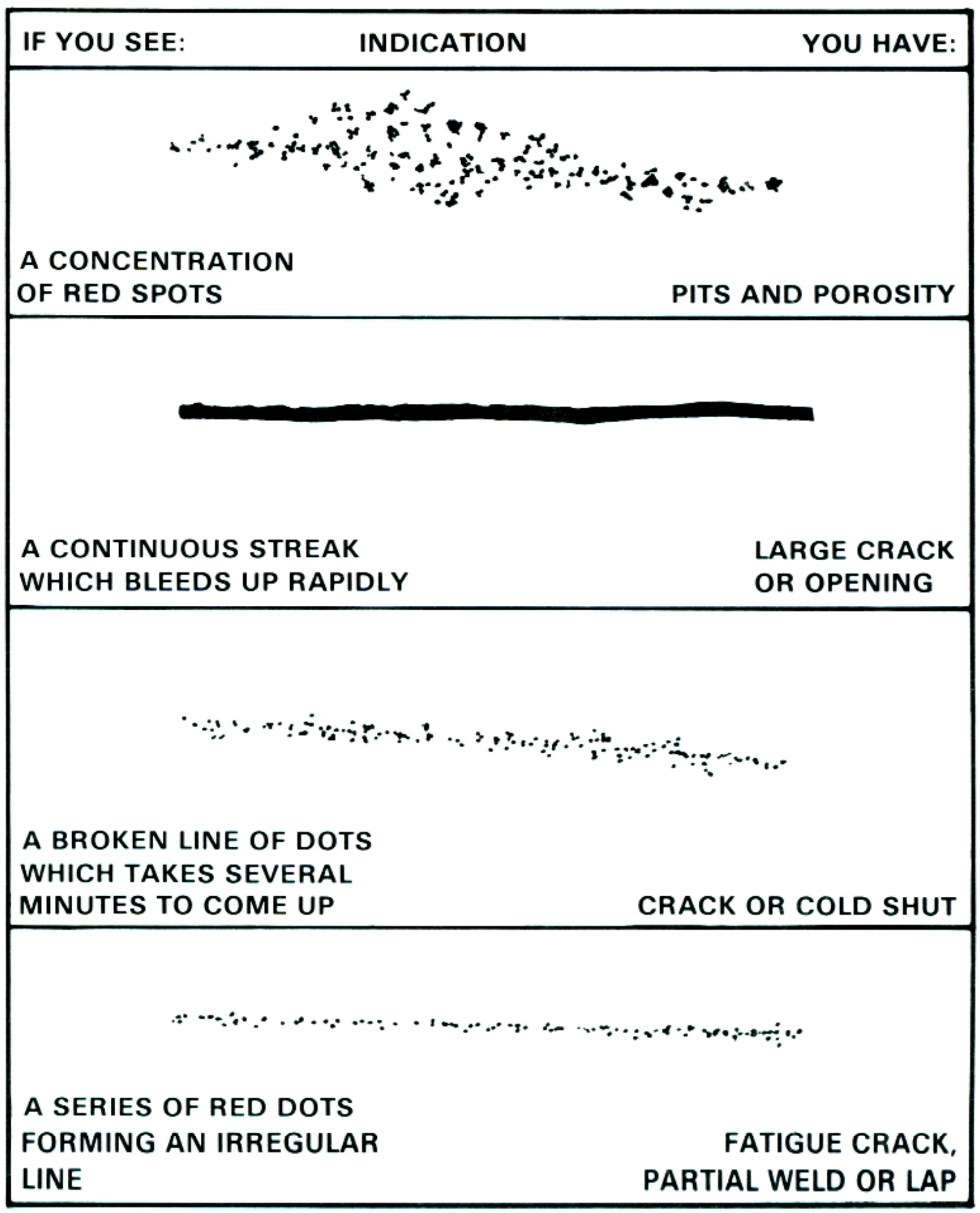


Developer applied

(1-4)

Visual examination and interpretation.

Here the real skill of the inspector can tell whether the indication is a crack, lack of fusion, porosity, etc. (see1-5)shows examples of indications types.



(1-5)

Uses

This test method is used to find fatigue cracks, shrinkage cracks, surface porosity, cold shuts, grinding and heat-treat cracks, seams, cold lap, and lack of fusion.

Penetrants

Additional things a inspector should know about this process. As indicated above, there are two types of penetrants, visible dye and fluorescent. There are also three methods of removing the applied penetrant.

The visible dye penetrant is usually red and is used with a white background developer. It is meant to be used under good quality lighting. Occasionally, it may be necessary to aid the naked eye with a magnifying glass for proper interpretation of the indicator.

The fluorescent penetrant has a yellow-green color that stands out clearly against the black background when viewed under "black light" (ultraviolet) in a darkened room. It is standard practice to let your eyes adjust to the dark for at least five minutes before trying to interpret a specimen. Some specifications may require that you allow your eyes to adjust to the dark for an even longer period.

Systems

To handle different applications for examination by liquid penetrant testing, there are now three basic penetrant systems within each of the two types. Nevertheless, the only basic difference between visible dye and fluorescent penetrant inspection is the method of viewing the results or indications.

Solvent Removable System.
This system is often used to inspect small areas. The ingredients are usually supplied in aerosol cans or sprays. They are available in pint, quart, and gallon containers. Required for aerosol use are a can of cleaner that is used in pre-cleaning and penetrant removal, a can of penetrant, and a can of developer.

In this method of inspection, the cleaner is sprayed onto the weldment and is allowed to spread for a few seconds. Then it is wiped dry with a clean, lint-free cloth or paper towel. It may be necessary to repeat this several times to make sure that the part is clean and free of contaminants. A light coat of penetrant is then applied. The penetrant is allowed to dwell for the manufacturer's recommended time. After the dwell time, the excess penetrant is wiped from the surface with a clean, free cloth or paper towel. Another cleaned cloth is dampened with cleaner and is used to wipe the surface until all of the penetrant except that within the discontinuities has been removed. If a fluorescent penetrant is used, you should remove it in a darkened area while checking your progress under ultraviolet light.

Caution! If you spray the cleaner directly on the surface, it will remove penetrant from the discontinuities, thus leaving no indication, and the result will be a false reading.

Once the part is cleaned and dried, a thin coat of developer is sprayed evenly on the surface. **Caution! If too much developer is used, it will mask or hide the smaller indications, which will again result in a false indication.** The developer must dry and should be given about one-half the penetrant dwell time to produce complete indications. Larger indications will show immediately. As you may have guessed, this system gets its name from the fact that the penetrant must be removed with a solvent, which is both the cleaner and the removal agent.

Water-Washable Penetrant System.

This system also gets its name from the method of penetrant removal. The penetrant has a built-in emulsifier that makes it water-washable. The steps are basically the same. Pre-cleaning must be done with a suitable solvent or by vapor degreasing. The penetrant is removed with a coarse, low-pressure water spray directed at a 45^0 angle to the surface. It is essential that all of the penetrant be removed from the surface; however, it is just as essential that the part not be over washed. This system is ideal for quick, efficient inspection of many parts, although it is not as sensitive as the solvent system. It is usually performed using large dip vats and spray booths.

Post-Emulsifiable Penetrant System.

This penetrant is oil based and, therefore, does not wash off readily with water. When an emulsifier is added to the oil penetrant, it chemically converts so that it becomes water-washable, much as soap affects greasy hands.

To use this system, the emulsifier is applied to the penetrant after the penetrant dwell time. The emulsifier dwell is timed closely and then the penetrant is washed off with a coarse water spray. The advantage is that the penetrant inside a discontinuity is not emulsified and so resists premature removal.

No matter what system is used, PT technicians learn to correctly process the parts in a relatively short time. The evaluation and interpretation of results come from experience and from the able guidance of a qualified inspector. Table 1-1 shows graphically the steps for each of these processes.

Advantages

- Liquid penetrant inspection is extremely sensitive to surface discontinuities. This means that it will detect very small discontinuities. Also, there are few false or non-relevant indications on reasonably smooth surfaces.
- The shape of the item or part is not a problem. The liquid penetrant method works as well on round surfaces as it does on flat ones.
- Liquid penetrant inspection is relatively easy to use. The average person can learn to use this process in a week or two. The learning to interpret the process may take somewhat longer.
- Visual contrast is greatly increased by the red dye against the white developer, and by the fluorescent dye viewed with black light.
- Liquid penetrant inspection is relatively inexpensive, reasonably rapid, and portable.

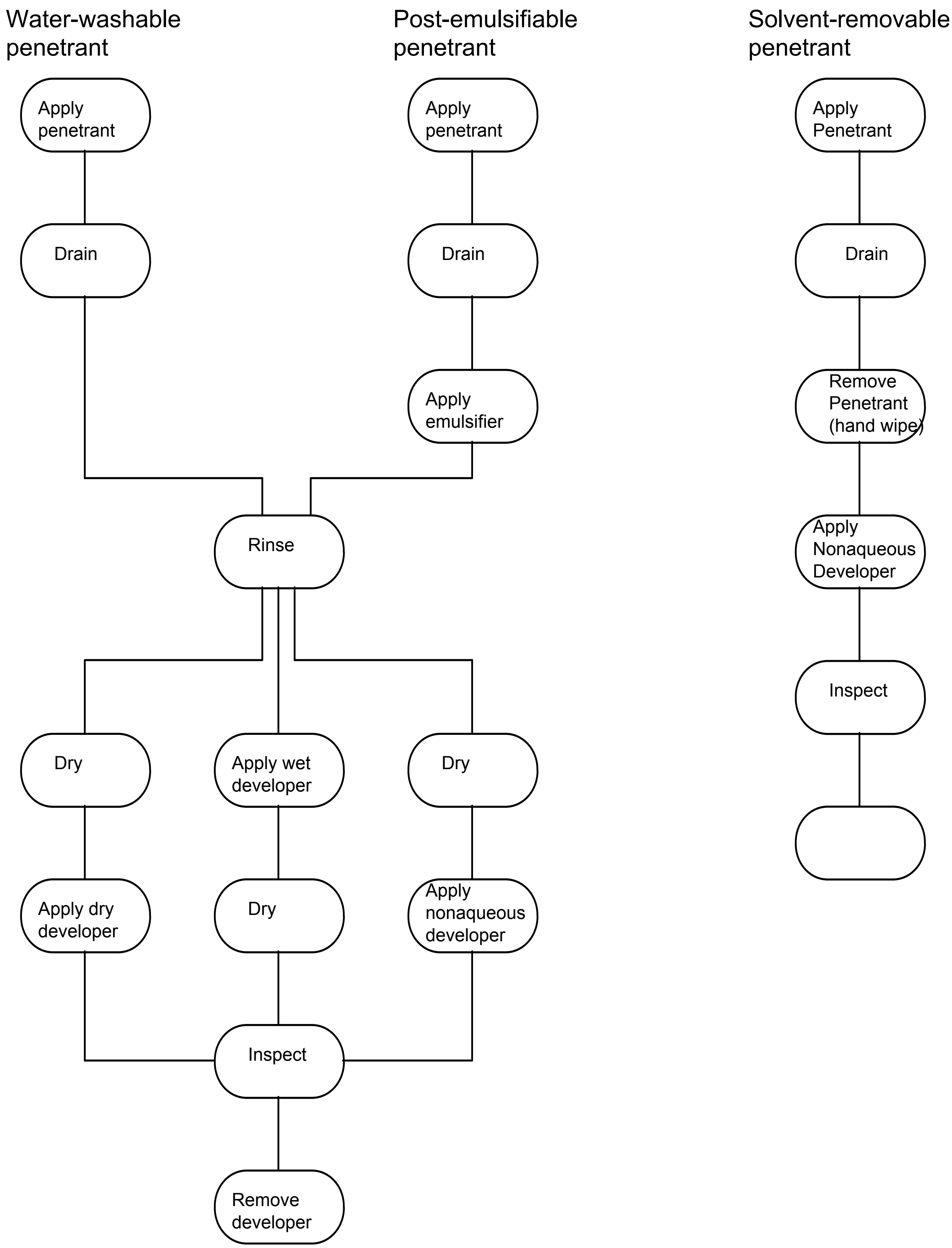
Limitations

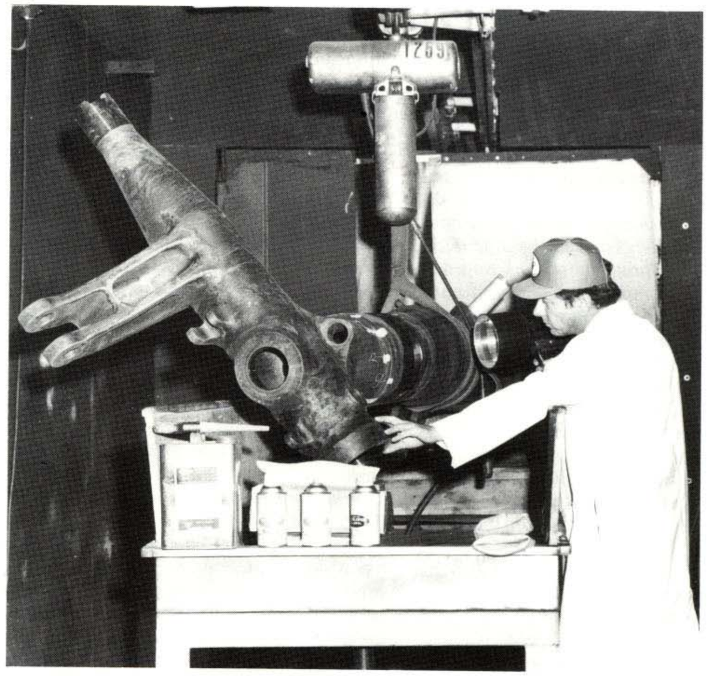
Discontinuities must be clean and open to the surface. Discontinuities under the surface, such as porosity, will not be detected.

There are no easy methods of producing a permanent record; the record is an important part of an inspector's responsibility. The recent advances in digital photography will ease the recording of indications.

Residual penetrant in the discontinuities may be deleterious in service or to the end use of the weldments; penetrants are difficult to remove completely.

Table 11- 1


Water-washable penetrant
Post-emulsifiable penetrant
Solvent-removable penetrant
Apply penetrant
Drain
Apply penetrant
Drain
Apply emulsifier
Apply Penetrant
Drain
Remove Penetrant (hand wipe)
Apply Nonaqueous Developer
Inspect
Rinse
Dry
Apply wet developer
Dry
Apply dry developer
Dry
Apply nonaqueous developer
Inspect
Remove developer



Inspector examines PT indications on flash weld in outer cylinder of Boeing 767 main landing gear. Courtesy Cleveland Pneumatic Company.

Know your welding NDT -Penetrant Testing

Liquid penetrants search out small surface defects and reveal them clearly by dye tints or fluorescence

Liquid penetrant testing (PT) locates surface flaws, even the finest, in all nonporous materials—metals and alloys, ceramics, plastics, and glass, to name a few. Weld shops often supplement magnetic particle testing with PT, because the penetrants work on austenitic stainlesses and nonferrous metals and alloys, which MT cannot touch. Technicians find the method easy to learn, and inspectors interpret indications with little effort.

How PT works

In its simplest form, penetrant testing requires a liquid penetrant to enter the discontinuity, and a developer, usually a fine powder, to pull the penetrant out of the discontinuity, reproducing its shape and size against a contrasting background. To extend application of PT, users can choose between fluorescent penetrants, which work with black light, and dye penetrants, which work under conventional illumination. Both types of penetrants can be water-washable (rinsed off by water, dipped or sprayed on the part), post-emulsifiable (rendered emulsifiable in water by an additive for water rinsing after application), or solvent-removable (cleaned off by a solvent, rather than by water). Each type of penetrant and each of the three testing procedures has its advantages and drawbacks, which the user should consider before selecting PT equipment and materials for an application.

Penetrant testing requires these steps:

- Clean the surface of the test piece to remove dirt, oil, and other contaminants that might fill discontinuities to prevent penetrants from entering.
- Apply penetrant, covering the area to be inspected.
- Wait the prescribed dwell time.
- Rinse, to remove excess penetrant from the surface.
- Apply developer, to pull penetrant out of the discontinuities.
- Inspect, to locate indications, which stand out against the background, usually white, of the developer.

Cleaning comes first

Do not minimize the importance of cleaning, essential because PT is useless unless penetrants can enter discontinuities. When choosing a cleaning method, consider the type of contaminant, effect of cleaning on the parts, practicality of the cleaning method for the parts, and requirements of the customer. ASTM E165, *Standard Recommended Practice for Liquid Penetrant Inspection Method,* describes several suitable cleaning techniques, including detergent cleaning, solvent cleaning, vapor degreasing, alkaline cleaning, ultrasonic cleaning, paint removal, mechanical cleaning, surface conditioning, and acid etching. Each type works on different kinds of surface contaminants, so pick the cleaner, or combination of cleaning agents, to suit the job.

Surface condition is also important—smooth surfaces reveal clear, sharp indications. Despite washing or solvent cleaning, ridges and valleys of rough surfaces, smoothed only by coarse grinding perhaps, may hold penetrant, producing false indications and obscuring backgrounds to confuse inspectors. Rough weld reinforcements may need to be smoothed for PT examination because of this effect.

Fluorescents or dyes?

Choosing a penetrant, the inspector faces a basic decision—should he use fluorescent penetrants for better sensitivity or dye penetrants for their convenience? Glowing a bright yellow-green against dark backgrounds, fluorescents give exceptional sensitivity for locating flaws. Complicating the inspection, however, technicians must examine surfaces by black (ultraviolet) light under hoods to shut out ambient light.

Indications brought out by dye

PENETRANT TESTING DEMANDS CLEAN SURFACES

Test parts require thorough cleaning to open discontinuities for penetrants. Because contaminants—dirt, oil, scale, and grease, to name a few—clog discontinuities, technicians must choose the cleanser and cleaning method with care. ASTM E165, *Standard Recommended Practice for Liquid Penetrant Inspection Method*, offers these tips on cleansers and their characteristics.

Detergents, nonflammable water-soluble compounds, contain surfactants that wet, penetrate, emulsify, and saponify organic contaminants, including greases and oils. Cleaning time averages 10 to 15 minutes at 170 to 200 F with moderate agitation, using concentrations according to manufacturers' recommendations.

Solvents, organic liquids such as alcohol and kerosene, dissolve oils, greases, waxes, and similar organic materials. Effective at ambient temperatures, they can be used in dipping tanks or hand-wiped with lint-free cloths.

Vapor degreasing uses boiling chlorinated solvents—typical is 1, 1, 1-trichloroethane which boils at 167 F. Hot vapors clean away oils and greases, leaving clean, dry parts which must cool below 125 F for inspection.

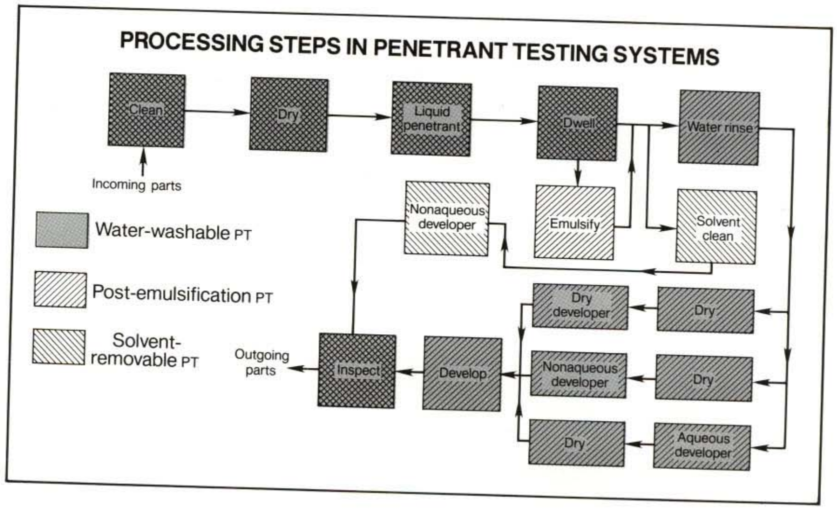
Alkaline cleaners, nonflammable water-soluble compounds, contain additives that help to clean off soil and remove scale and rust when hot. Cleaned parts must be rinsed in water, dried, and cooled to below 125 F for testing.

Steam cleaning, a modification of hot-tank alkaline cleaning, removes soil from large, unwieldy parts.

Ultrasonic cleaning aids detergent and solvent cleaners to remove inorganic materials (rust, dirts, and salts) and organic compounds (oils and greases), speeding operations by agitating hot solutions. Technicians cool parts to 125 F before testing.

Mechanical cleaning and surface conditioning remove carbon, rust, scale, and foundry sands, which stick to castings. Processes, which often remove metal as well, include filing, buffing, scraping, grinding, sanding, deburring, and blasting with abrasives such as sand, glass beads, and metallic shot. Surface working may inhibit testing by peening over discontinuities to prevent penetrants from entering, especially on soft metals such as aluminum and magnesium.

Acid etching, which employs inhibited acid solutions, removes oxide scales and peened metal that mask discontinuities to prevent penetrant entry. Before testing, rinse off etchants, neutralize surfaces, and dry—acids and chromates dim fluorescence.



penetrants, on the other hand, show up clearly under conventional light, without need for hoods and special lighting equipment. Inspection by dye is so simple in fact that NDT suppliers have developed PT spray-can kits for field and shop use. They also offer portable kits for fluorescent penetrant inspection, but these include ultraviolet lamps that require access to electrical power.

The inspector chooses penetrants to find the types of defects he is looking for. For critical applications, such as spotting small cracks on stress-bearing aircraft components, companies go the fluorescent route. Pratt & Whitney Aircraft Division, United Technologies Corporation, installed, at the PWA Southington (Conn.) plant, an automated fluorescent penetrant testing complex that tests 20 models of jet engine rotors of various sizes and shapes. Operations, computer-controlled, detect small flaws in i.d. weld areas of nickel-alloy and titanium drum rotors weighing up to 400 pounds. Engineered by Magnaflux Corporation, Chicago, the Zyglo processing system consists of penetrant spray and drain stages, two spray rinses, three drying stages, a dry developer stage, and load and unload stations; inspection for indications follows unloading.

Dye penetrants suffice when profitability and convenience override the need to find the finest of cracks. The fastest, simplest PT method, water-washable dye testing, is also the least sensitive, because water rinsing may remove penetrant from cracks before the inspector applies the developer to reveal indications.

From cleaning to inspection

Once the inspector chooses the penetrant, he selects one of three PT methods, water-washable, post-emulsification, or solvent-removable, all of which work with either penetrant type. The methods resemble each other in most respects, differing only in details.

As the diagram shows, all methods start with cleaning, drying, penetrant application, and holding, to allow discontinuities to absorb penetrant. The post-emulsification method requires an extra step, addition of emulsifier. The solvent-removable method adds two steps, for solvent cleaning and application of a nonaqueous developer, but skips the developer-application steps of the other PT methods. Technicians examine all PT-processed parts in the same manner, looking for visible indications revealed by fluorescence or dyes.

Running a water-washable procedure, the inspector dips or sprays the part with liquid penetrant, allows time for penetrant to seep into discontinuities, then washes away the excess. After drying, he applies developer to bring out indications, which he examines to determine their significance.

Post-emulsifiable procedures use emulsifier-free penetrants, compounded to combine penetrability and stability within discontinuities. Adding emulsifier later, after a holding period, he cleans off surface penetrant without disturbing penetrant in discontinuities—this can happen when using water-washable penetrants, which contain built-in emulsifiers. Subsequent steps (rinsing, drying, developing, and inspection) duplicate those for water-washable procedures.

Permission to use requested from Welding Design & Fabrication — Verbally requested

Solvent-removable procedures employ organic solvents, rather than water, to remove surface penetrant. Nonaqueous developers, usually sprayed, bring out indications.

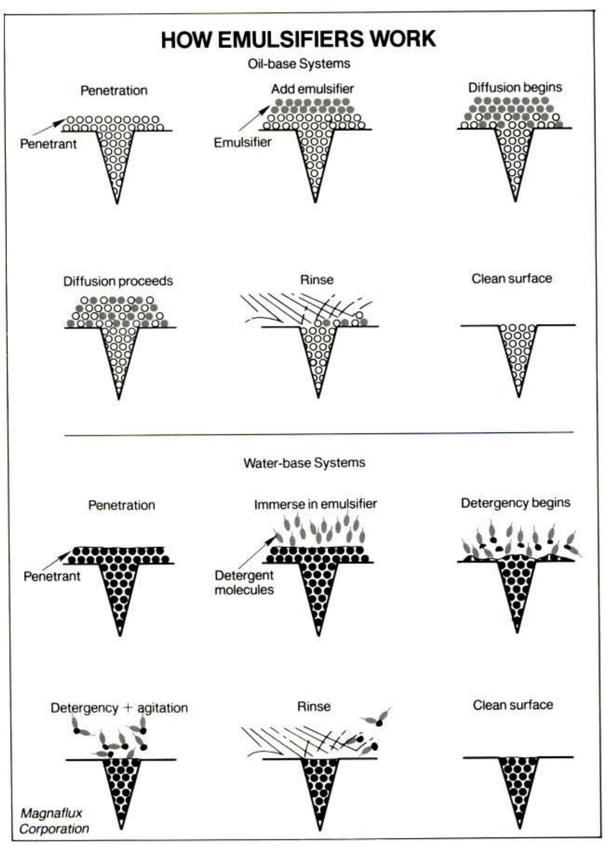
How PT methods compare

Considering the three PT methods, and their use with the two penetrants, we have six PT systems to discuss, in order of rising sensitivity and cost:

Water-washable dye systems, fast and simple, provide least sensitivity, because water can wash penetrant from wide, shallow cracks before development. Inspectors can also miss fine, tight cracks, which fluorescent methods detect.

Solvent-removable dye systems provide portability, making them useful for field inspection. Because solvents come in easily carried cans, as do penetrants and developers, solvent-removable systems work almost everywhere. Difficulty of penetrant removal, however, limits the method to spot and field inspection where other methods are impractical.

Post-emulsifiable dye systems provide the best sensitivity of the dye penetrant methods, because penetrant remains in discontinuities for subsequent development, not washing away during rinsing. The added step of emulsification, however, increases cost.



Water-washable fluorescent penetrant systems gain sensitivity from the added brilliance of fluorescent particles under black light, plus speed and convenience from the use of water alone to rinse parts. Costs rise, owing to needs for black light facilities, inspection hoods, and a water source.

Solvent-removable fluorescent systems find use where inspectors need the sensitivity of fluorescence plus the convenience of water-free cleaning. Like its dye-penetrant counterpart, the method suits spot inspection tasks, but electric power and light-tight viewing hoods for black-light inspection must be available.

Post-emulsifiable fluorescent penetrant inspection is tops in sensitivity, spotting wide, shallow grooves as well as fine cracks. Extra costs accrue from the need for an emulsifying step as well as the requirement for inspection by black light under a hood.

Materials for penetrants

. . . vary with the penetrant mission and application method. Penetrants consist of penetrating oils to which manufacturers add fluorescing materials or dyes, usually red for high visibility. Water-washable penetrants, fluorescent or dye, also contain emulsifier that make it easy to wash off excess penetrant. Penetrants for post-emulsifiable systems lack emulsifiers, so they remain in discontinuities while inspectors water-wash surface penetrant away.

Emulsifiers, whether they are components of water-washable penetrants or separate solutions for post-emulsifiable systems, condition penetrants for mixing in water. Emulsified, oil-base penetrants break down into small globules that wash away easily when sprayed with water or dipped in it.

Permission to use requested from Welding Design & Fabrication — Verbally granted

Suppliers offer two types of emulsifiers, oil-base (lipophilic) and water-base (hydrophilic). Operators apply oil-base emulsifiers directly to penetrant-coated parts, where they diffuse at rates that vary with their viscosities. High-viscosity emulsifiers take 2 to 4 minutes to diffuse, low-viscosity types take less than 2 minutes.

Water-base emulsifiers, somewhat more economical than oil-base types, mix with water for use. Dilutions run half-and-half to 5 percent emulsifier-95 percent water. Technicians spray diluted water-base mixtures on workpieces, washing away excess penetrants by detergent action. They also use water-base emulsifiers in tanks, agitating baths with air to remove surface penetrants.

Bath concentrations of water-base emulsifiers vary with the application, according to James S. Borucki, national sales manager, Magnaflux Corporation. Pratt & Whitney Aircraft, he says, prefers 1/3 emulisifier to 2/3 water, General Electric Company, 20 percent emulsifier, and Rolls-Royce, 5 percent. Used in sprays, concentrations run lower, from 0.05 to 1 percent.

When determining emulsification periods for a given application, start with times recommended by the manufacturer. Then wash or spray for different periods to determine optimum time, which may run from a few seconds to several minutes.

Using solvent removers

Solvents, flammable and nonflammable organic liquids, dissolve penetrants. Though free of contaminating halogens such as chlorine, flammable solvents are fire hazards. Containing chlorinated solvents, nonflammable cleaners are forbidden for use on alloys susceptible to stress corrosion cracking.

To remove surface penetrant, wipe with a lint-free cloth soaked lightly with solvent remover, being careful not to wash penetrants out of cracks. Among flammable solvents, kerosene, less active than naphtha, removes surface penetrant without dissolving penetrants in fine cracks, but will absorb penetrant in open defects.

To make sure that no excess penetrant remains, wipe the surface twice, using a clean cloth and fresh solvent each time. View surfaces under black light to check cleaning progress with fluorescent penetrants. After cleaning, allow time for the solvent to evaporate, leaving the surface dry for the developer.

Developing indications

Compounded to absorb penetrants in discontinuities, bringing them to the surface to view as indications, developers come in four types: dry, water-suspendible, water-soluble, and solvent-suspendible. Dry or suspended in a solution, developer powders perform these functions:

- Blot penetrant, drawing it from surface openings.
- Provide a base of contrasting color, usually white, over which the penetrant can spread for easy visibility.
- Cover confusing backgrounds and reduce glare, which may inhibit interpretation.
- Remove penetrant from discontinuities and surface.

Dry powders find wide use with fluorescent penetrants, but are rarely employed with dye penetrants. They should be light and fluffy, clinging to dry surfaces in thin films that penetrants can work through when absorbed from discontinuities. The finer the powder, the more sensitive the test, because layers of fine-grained powder absorb penetrant more efficiently. The technician must avoid coating the part too heavily with dry powder, otherwise small quantities of penetrant in fine cracks may not penetrate the layer to become visible.

Powders are usually white, though manufacturers sometimes tint them for identification —color is unimportant for fluorescent inspection, because technicians use black light. For storage and handling ease, powder makers avoid hygroscopic materials which would cake, ceasing to flow in high-humidity atmospheres.

Wet developers, suspensions of powder in water or a solvent, find favor for their convenience, being applied by spray, flowing, or dipping. Using a water-suspendible developer in a tank, the technician can dip a basket of small parts after washing away excess penetrant. As parts dry, penetrant emerges from discontinuities to show up as clear indications against the developer film. Manufacturers furnish water-suspendible developers as dry powders, which users add to baths in recommended proportions, up to 1 pound per gallon. To remove dried films after inspection, spray parts with water or wash them mechanically with detergents.

Water-soluble developers hold to steady concentrations, unlike water-suspendible types, in which powders are difficult to hold in uniform suspensions because they settle. Some difficulties exist with fluorescent penetrants, because indications may be dimmer than those produced by water-suspendible developers. Water removes dried films, usually with ease.

Solvent-suspendible developers, also called nonaqueous developers, use quick-drying solvents for propellants, so suspensions do not run when deposited. These developers find use in portable PT kits, usually with dye penetrants, because they work well in pressure spray cans. Sprayed onto clean, dry surfaces, the volatile solvent evaporates, leaving a dense coating of white powder. As do other developers, the powder draws penetrant out

PICKING A PROPELLANT

Field PT inspectors frequently use aerosol cans to spray penetrant materials on workpieces, looking for surface defects. Before 1978, when the EPA banned Freon propellants in aerosol spray cans, makers of penetrants and most other aerosol-conveyed products used this non-flammable propellant. After the ban, over 95 percent of the aerosols canned in the U.S. switched to hydrocarbon propellants, approved by the Consumer Products Safety Commission.

Those concerned with flammability of hydrocarbons, such as technicians who inspect welds in confined areas, should consider the difficulty of reaching lower flammability limits of hydrocarbon propellant in air, 2 percent, or 20,000 ppm. To attain it, the inspector would have to discharge the entire can in a 75-cubic-foot volume (4-1/4 by 4-1/4 by 4-1/4 feet). However, the OSHA maximum-allowed level for the solvent, 15-minute exposure, is 450 ppm, because higher concentrations reduce work efficiency. Since the lowest flammability limit, 20,000 ppm, is 45 times the OSHA-allowed limit, it is unlikely that an inspector would spray enough propellant to reach that quantity.

Penetrant manufacturers have a nonflammable alternative, carbon dioxide, which is also cheaper than hydrocarbon propellant. However, carbon dioxide, a compressed gas, atomizes the developer poorly in comparison to hydrocarbon propellants. Propelled by gas pressure, developer liquid sprays out of the nozzle, but further atomization is limited. Also, gas pressure begins to drop when the operator starts using the can, lowering the discharge rate and atomization as the can empties.

Containing hydrocarbon propellant, a full can of developer holds liquid solvent and the propellant, both mutually soluble. Push the little valve down, and pressure forces the solution up the dip tube to spray out of the nozzle in fine droplets. Because the expelled liquid contains both developer and propellant, confined above its boling point, droplets explode as the propellant spurts from the nozzle and vaporizes. This type of aerosol spray produces a thin, uniform, coating of PT developer.

Phillip J. Mattex, vice president
Met-L-Chek Company
Santa Monica, Calif.

of discontinuities, outlining them as bright indications against a white background. Examination completed, powder washes off by water or solvent.

Choosing a developer

Here are general rules for developer selection, taken from *"Nondestructive Inspection and Quality Control," Vol. 11, ASM Metals Handbook, 8th Edition:*

- Use wet developers, rather than dry, on smooth surfaces—dry powders stick poorly.
- Use dry developers on rough surfaces, on which they adhere well; wet developers are also difficult to clean off if reinspection becomes necessary.
- Use wet developers to inspect large numbers of small parts at rapid rates, because they are faster and easier to deposit than powders.
- Avoid wet developers when inspecting sharp fillets, which collect liquids.
- Use solvent-suspendible developers to spot fine, deep cracks; however, they are less effective for finding wide, shallow grooves.

Penetrants find weld defects

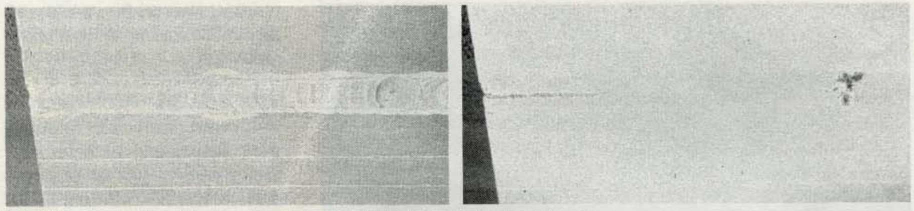
. . . with ease, clearly outlining their shapes and sizes for easy interpretation, just as magnetic particle tests do. Starting the PT procedure, the technician thoroughly cleans the parts. Next, he covers the part with an even coating of penetrant by flowing, brushing, dipping, or spraying. He usually dips small pieces, often held in baskets, and sprays or brushes large items. Penetration time varies with the alloy and type of discontinuity, usually running from 2 to 30 minutes; 15 minutes is average. After coating the part, the technician drains off excess penetrant.

Dwell times for penetrants vary with crack size, surface cleanliness, and penetrant viscosity. Minimums of 5 minutes usually suffice for castings, 10 minutes for wrought alloys.

Next comes rinsing. During this critical step, the technician must be careful to remove all excess surface penetrant, yet avoid washing penetrant out of discontinuities. To assure reproducible results, so that indications will correlate with discontinuity sizes with each test run, he must follow the same operational sequences time after time.

Water-washable penetrants come off with water sprays and dips, using manual or automatic procedures. Rinsing under black light makes it easy to determine when surfaces are free of excess fluorescent penetrants. Times, determined experimentally, vary from 15 seconds to 2 minutes for specific workpieces. Limit spray pressures to 30 lb /in.^{2}; more than 50 lb/in.^{2} washes penetrant from cracks. To reduce chances for washing penetrant out of flaws, direct sprays at low angles to surfaces. Water temperature should be 60 to 105 F.

Permission to use requested from Welding Design & Fabrication — Verbally granted



Visually examined, weld appears satisfactory (left), but penetrant testing reveals crater cracks and longitudinal center crack. Courtesy Uresco Ardrox.

Before applying a dry or nonaqueous developer, the technician must dry the rinsed workpiece. Though he can use one of several methods (hot-air oven, hot-air blasting, even exposure to ambient temperature), experts recommend thermostatically-controlled recirculating hot-air driers. Technicians should, they say, control the air temperature between 175 and 220 F, keep the workpiece below 175 F, and remove the part as soon as it dries, usually within minutes. It's good practice to determine precise drying times by experiment.

Developing indications

Technicians using wet developers need not dry parts, because they can dip, flow, or spray the part with developer as soon as they clean workpiece surfaces of excess penetrant. They should maintain bath concentrations at manufacturer-recommended levels, normally 1/2 to 1 pound per gallon. To check concentrations, monitor specific gravity with a hydrometer. Dip parts for enough time to coat all surfaces, then drain excess developer from recesses and traps. When spraying or flowing developer, avoid washing penetrant from cracks.

Technicians apply dry and solvent-suspendible developers after the workpiece dries. To apply dry powders, they immerse, spray, or use a dust tank, coating the part completely with a thin, even layer. Then, they shake, tap, or gently air-blast the part to remove excess powder. Sprayed on parts by spray gun or aerosol containers, solvent-suspendible developers dry within seconds at ambient temperatures, leaving a thin film of powder.

Once the film forms, penetrant begins to ooze out of discontinuities, outlining their shapes and sizes. Technicians usually allow 10 minutes for full development. Longer periods let indications spread out and diffuse to such an extent that they become difficult to interpret.

Post-emulsion PT

. . . follows the same procedures as water-washable PT, plus addition of emulsifier after coating the part with penetrant. Immediately following the dwell period, technicians should dip, spray, or flow the part with emulsifier, covering the entire surface as soon as possible. Though not considered critical, temperatures should hold between 70 and 90 F.

Emulsification times range from 15 seconds to 4 minutes, depending on the type of emulsifier (fast-acting, slow-acting, oil-base, or water-base) and surface roughness. To determine optimum dwell time, start with manufacturer's recommendations and hold for different periods to establish the time needed to emulsify the surface penetrant without washing away penetrant in discontinuities. Rinse emulsified penetrant as with water-washable systems.

Interpreting indications

To interpret PT indications accurately, the inspector needs good eyesight plus knowledge of welding defects to evaluate the types of discontinuities revealed by the indications and their effect on the parts being examined. He must illuminate indications clearly, especially when examining fluorescent-tested surfaces. Working in a darkened room or under a light-tight hood, he uses black light (320-400 nm wavelength) at the recommended intensity, 600 to 1,000 microwatts per square centimetre. Before starting to examine parts, he should allow the lamp to warm up for 10 minutes to reach full power, using the delay to adjust his eyes to darkness. Viewed in darkness under black light, fluorescent indications glow a brilliant yellow-green.

Dye-penetrant indications show, under bright light, a vivid red against the white background of the developer. Experts recommend illumination of 30 to 50 foot-candles for optimum visibility.

Useful inspection tools include rules, a flashlight, small quantities of solvents and different types of developers, pocket magnifiers (3X to 10X), and portable lamps for viewing fluorescent and visible-dye indications. Technicians also use photographic standards and workpieces with known flaws for comparisons.

One aid, issued by the Ameri-

Permission to use requested from Welding Design & Fabrication — Verbally requested

PENETRANTS REVEAL SURFACE DISCONTINUITIES

Type	Locations	Appearance
	Relevant indications	
Shrinkage cracks	Castings — flat surfaces	Open
Hot tears	Castings — inside corners	Open
Cold shuts	Castings — changes in cross section	Tight, shallow
Folds	Castings — anywhere	Tight, shallow
Inclusions	Castings, forgings, sheet, bar—anywhere	Tight, shallow, intermittent
Microshrinkage pores	Castings—anywhere	Spongy
Laps	Forgings, bar—anywhere	Tight, shallow
Forging cracks	Forgings—at inside or outside corners and at changes in cross section	Tight or open
Pipe	Forgings, bar—near geometric center	Irregular shape
Laminations	Sheet—at edges	Tight or open
Center bead cracks	Welds—at center of reinforcement	Tight or open
Cracks in heat-affected zone	Welds—at edge of reinforcement	Tight or open
Crater cracks	Welds—at end of bead	Star-shaped
Porosity	Castings, welds	Spherical
Grinding cracks	Any hard metal—ground surfaces	Tight, shallow, random
Quench cracks	Heat treated steel	Tight to open; oxidized
Stress-corrosion cracks	Any metal	Tight to open; may show corrosion
Fatigue cracks	Any metal	Tight
	Nonrelevant indications [a]	
Weld spatter	Arc welds	Spherical or surface
Incomplete penetration	Fillet welds	Open, full weld length
Surface expulsion	Resistance welds	Raised metal at weld edge
Scuff marks	Seam welds	Surface of seam welds
Press-fit interface	Press fits	Outlines press fit
Braze runoff	Brazed parts	Edge of excess braze
Burrs	Machined parts	Bleeds heavily
Nicks, dents, scratches	All parts	Visible without penetrant aids

a. These may be prohibited flaws, but are usually considered nonrelevant in penetrant testing.

Source: "Nondestructive Inspection and Quality Contol;" Vol. II, Metals Handbook, 8th Edition, American Society for Metals

can Society for Testing and Materials, is ANSI/ASTM E433, *Standard Reference Photographs for Liquid Penetrant Inspection.* It classifies PT indications into Type I (those in which neither measurable dimension is three times greater than the other) and Type II (those in which one measurable dimension is greater than three times the other). Within each type, E433 lists classes of indications: A, single; B, multiple unaligned; C, multiple aligned; and D, intersection of surfaces, as occurs with threads, corners, and fillets. The spec provides photos that show indications in each of the two types and four classes.

Beginning his inspection, the inspector scans the workpiece rapidly to make sure that it has been properly processed for examination. Then he carefully studies each indication, often measuring and gaging to make sure that it falls within specifications. Questionable indications may be wiped off and retested to verify relevance and size.

The inspector looks for discontinuities such as crater cracks, cracks along beads and in heat-affected zones, porosity, and undercut. PT also spots spatter, incomplete penetration, surface expulsion (resistance welds), and scuff marks (seam welds), but an inspector must use other nondestructive testing methods to determine if the part must be rejected because of these.

Inspectors usually interpret PT indications with ease, because indications duplicate the discontinuity. Indications of cracks run along bead centers or at the sides, in heat-affected zones; porosity appears as scatterings of small spots; and crater cracks produce star-shaped patterns. Dimensions, other than length, cannot be determined accurately.

Because indications spread with time, widths do not necessarily relate to depth of discontinuity, as do magnetic particle indications of cracks. Experienced inspectors, however, can tell deep flaws from shallow types. Because they contain more penetrant, deep flaws produce wider indications that spread more rapidly.

As with magnetic particle testing, PT inspectors must watch out for irrelevant indications. Surface irregularities such as spatter, indentations in rough surfaces, burrs, nicks, dents, and scratches collect, concentrate and retain penetrants just as cracks and

---

Permission to use requested from Welding Design & Fabrication — Verbally requested

PENETRANTS DETECT LEAKS

The ability of liquid penetrants to filter through the smallest of holes, even microscopic pores, suits them for leak detection. Users include builders and operators of nuclear reactors, pipelines, chemical processing vessels, refrigeration equipment, hydraulic cylinders for aircraft controls, and other pressure systems that must be leak-free. While penetrant tests lack the sensitivity of mass spectrometer inspection, they provide convenient leak detection at moderate cost.

Standard fluorescent and dye penetrants, especially the post-emulsion types, find leaks easily. Where there is no need for water washability, technicians prefer post-emulsion penetrants, which are compounded strictly for penetrating properties. Red-dyed penetrants, especially fluorescent types, help to spot leaks, because the color stands out against light and dark backgrounds. Red fluorescence differs from that emitted by contaminants—oils and greases fluoresce blue-white to blue-green.

To find leaks in pressurized systems, such as pipes and reactor vessels, fill the vessel with the penetrant, or with a penetrating liquid. Then apply a developer, powder or solution spray, on the outside surface, wait the specified period, and examine. Should a red mark or glowing spot indicate a leak, wipe it away, and wait for it to reappear, proving its presence. After testing, flush the vessel to repair leaks or to activate the system. Where dyes or fluorescent materials do not affect equipment operation, they may be added permanently to hydraulic fluids, so that technicians can check for leaks at any time during the operating life.

Fabricators also use penetrants to detect leaks while constructing pressure-bearing equipment. Testing small vessels, they slosh penetrant around the inside, cover the outside with developer, wait for penetration,and examine for leak indications. To leak-test large vessels and pipes, they paint or spray outsides of seams with penetrant, insides with developer, wait for penetration, and examine. Finding and repairing leaks during construction usually assures leak-free performance throughout hydrostatic testing, which completes inspection.

When fabricating small cases and tanks, the welder can become his own inspector by using fluorescent penetrants in spray cans. Completing a weld, he sprays it with penetrant and waits for penetration—from 2 to 5 minutes for thin sheet, up to an hour for plate. For thicker welds, he may need to apply more penetrant in 30 minutes, adding enough extra to penetrate to the opposite side.

other relevant discontinuities do. With incomplete washing, they develop to fluoresce in the dark or stand out in red against a white background to mislead the inspector. To guard against this possibility, which can also occur with properly cleaned parts, the inspector should know enough about part fabrication to recognize that irrelevant indications might appear. To tell the difference between relevant and nonrelevant indications, he swishes the area lightly with a camel's hair brush wet with trichloroethane solvent, removing the suspect mark. Relevant indications reappear, bleeding to the surface immediately, while areas that contain superficial marks remain clean.

Codes and specs

Inspectors refer to ASME, AWS, and other codes, as well as manufacturers' specifications, to determine whether a PT indication relates to a rejectable defect. AWS D1.1, *Structural Welding Code—Steel,* stipulates that PT findings should be evaluated as are those of visual inspection, which call for visible discontinuities to be measured to determine acceptability. For procedures, the code refers the inspector to ASTM E165, *Standard Recommended Practice for Liquid Penetrant Inspection.* Section V, *Nondestructive Examination,* of the ASME Boiler and Pressure Vessel Code mandates a number of requirements:

- PT materials must be approved before use. Penetrants for nickel-base alloys are to be tested to ASTM D129, *Test for Sulfur in Petroleum Products (General Bomb Method),* while those for austenitic stainlesses are tested according to ASTM D808, *Test for Chlorine in New and Used Petroleum Products (Bomb Method).* These tests verify that sulfur and halogens contents are below 1 percent—sulfur and chlorine cause stress corrosion cracking in nickel-base alloys and in stainless steels.
- Surface condition requirements call for as-processed textures (forged, rolled, welded, cast), though rough surfaces may need grinding to smooth them enough to reveal clear PT indications. Surfaces to be inspected and adjacent areas within 1 inch must be clean and dry, free of dirt, lint, welding flux, spatter, oil, and anything else that could interfere with testing.

Examination should, if possible, take place while adding the developer, because large discontinuities bleed and spread, making it difficult to evaluate their true size and type. Inspectors, says Article 6, must examine surfaces within 7 to 30 minutes after development begins.

- Qualification of procedures should be done within the preferred temperature range, 60 to 125 F. If the section in question, perhaps a cooling weld, cannot be examined within that range, the technician must qualify the procedure for use at the nonstandard temperature.
- Procedure requirements dictate written reports that record, at the least, brand names and designations of penetrant materials, details of pre-examination and cleaning, details of testing procedures and test temperature, details of penetrant removal and developer application, specified developer time, and method of post-examination cleaning.

Company standards

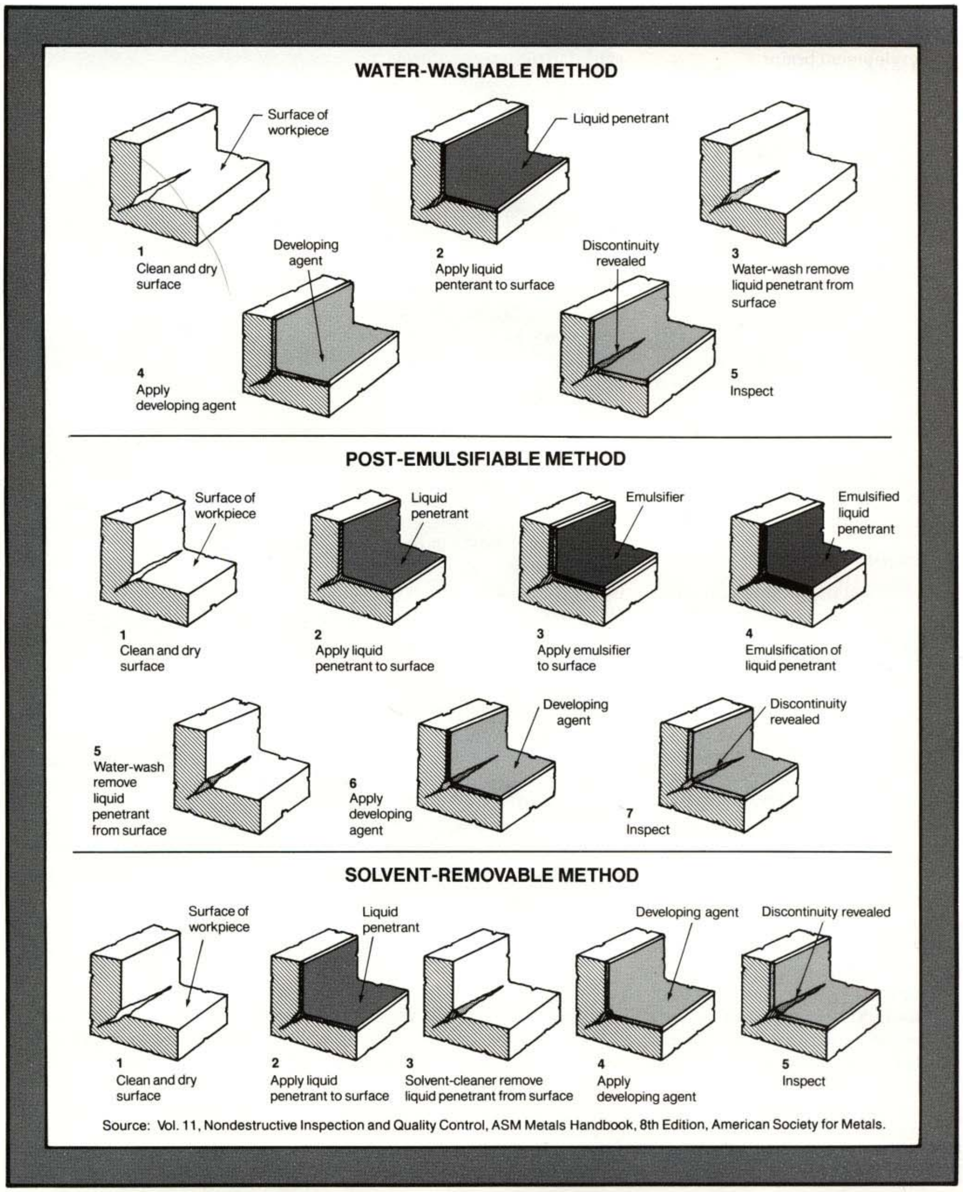
Fabricators that use austenitic stainlesses and nonferrous alloys often develop their own specs, especially when their products must withstand high stresses in service and safety is a major concern. Makers of aerospace equipment use stringent PT standards. Cleveland Pneumatic Company, a maker of landing gears for commercial and military aircraft, tests landing gear parts of 300M (a modified ASTM 4340) by MT and PT. Standards of the Cleveland-based firm limit discontinuities to 1/16 inch length per quadrant, and discontinuities must lie beneath the surface—surface defects can start fatigue cracks during service, especially during taking off and landing. The magnetic particle test locates discontinuities, and the penetrant test tells whether they reach the surface.

What's coming in PT?

Since the development of post-emulsifiable and solvent-removable materials and systems, the liquid penetrant technology has remained static. Manufacturers continue to refine the methods, producing penetrants, solvents, and developers that remain stable for long periods and produce clear, easy-to-interpret indications. Some are trying to extend testing temperatures, developing penetrants that work beyond both ends of the standard temperature range, 60 to 125 F. Magnaflux Corporation offers dye penetrant kits to test welds from freezing temperatures to 350 F. It also provides kits for applying the water-washable system in the field, where solvent-removable systems have been standard heretofore. Such kits come in handy for testing rough surfaces, difficult to clean with solvents. ■

welding engineer data sheet

Procedures for liquid penetrant inspection



Source: Vol. 11, Nondestructive Inspection and Quality Control, ASM Metals Handbook, 8th Edition, American Society for Metals.

Permission to use requested from Welding Design & Fabrication — Verbally granted

PT SELF STUDY - TRAINING PROGRAM **Name: ________________**

Liquid Penetrant

Answer each of the following questions in the space provided, or on the back of the page you are working on or on a separate sheet of paper. The answers should be brief but complete.

1. What type of material can be tested with the liquid penetrant (PT) method?

2. What is the function of the developer for a penetrant inspection system?

3. What is the main limitation of the PT method for locating discontinuities?

4. Give three examples of discontinuities that cannot be found using dye penetrant inspection?

5. In the old oil and whiting method what was the function of the chalk?

6. Describe in your own words what is to be accomplished in the first step of a liquid penetrant test.

7. How is rust and scale removed from a test object's surface in preparation for penetrant testing?

8. List four of the typical solvents used to remove oil and grease from test objects in preparation for testing?

9. What classification of solvents should not be used to clean stainless steel?

10. Ultrasonic cleaners with solvent as the solution are used to remove what type of contamination?

11. What are inorganic soils?

12. How does penetrant enter a discontinuity?

13. What property of a penetrant makes it flow over the object's surface and into small discontinuities?

14. Red penetrant is classified as what type of dye?

15. Why would one select a dual sensitivity penetrant for a particular test?

16. What is the proper way to apply penetrant to the test surface?

17. What is the most common way to apply penetrant to the test surface of large non-movable parts?

18. Define "dwell time”

19. What is the minimum acceptable dwell time when inspecting a mild steel weldment for cracks and lack of fusion?

20. When testing aluminum castings for cracks, what is the recommended minimum dwell time if test is conducted at 20ºC?

21. The red penetrant in spray cans used for field-testing is classified by which removal method?

22. Explain how the excess penetrant is removed when using post-emulsified penetrant.

23. What test is done to see if the correct amount of excess visible penetrant has been removed from test surface?

24. Why must the surface of a test object not be flushed with solvent to remove the final traces of visible dye?

25. When washing excess water-washable fluorescent penetrant from the object, how does one know when to stop?

26. Hydrophilic emulsifiers are added to what common substance and the mixture sprayed on to the test object's surface to remove excess penetrant?

27. What are the acceptable ways to apply an emulsifier?

28. Why are emulsifiers applied to penetrant?

29. How does one determine the correct emulsification time when using a post-emulsification penetrant?

30. Explain, which would be more harmful, a long penetrant dwell time or a long emulsification time.

31. Penetrant is drawn from discontinuities by which process?

32. List the types of developers that use some form of a liquid carrier?

33. When using a water-soluble developer, what is the recommended drying time between removing excess penetrant and applying the developer?

34. How is a hydrometer used to assure quality when using a water-soluble developer?

35. When using a wet developer at what point in time does the penetrant start to come out of the discontinuity?

36. When using a water-washable penetrant and a dry developer, why must the surface be dry before application of the developer?

37. Where does the "wet come from, for the nonaqueous wet developer if not from water?

38. Why is the nonaqueous wet developer the most sensitive developer for detecting fine?

39. What would be the best developer to use when testing the threaded part of a bolt?

40. Would the developing time be long or short when inspecting for tight cracks?

41. What type of welding defect might produce an indication that is a continuous line?

42. A "fixer" is used with what type of indication removal system?

43. What method would be employed in step six if the part were pre-cleaned with a rag and spot check cleaner?

44. Is post cleaning always the final step for a penetrant test?

45. What is the main limitation of liquid penetrant inspection?

46. In filtered particle testing, would the use of a nonaqueous wet developer aid in finding fine cracks? Explain why or why not.

47. How does "carry-over" affect contamination also give an example where this can occur?

48. Explain why post-emulsified penetrant system would have more of a contamination problem than the water-washable system if both use the same type of developer.

49. Which step in penetrant inspection would the chance of an accidental fire be the greatest?

50. When parts are cleaned using vapor degreasing are the parts placed in the cleaning solution if not how are they cleaned?

51. Why is dipping a good way to apply penetrant to the small parts when there are many of them to be inspected?

52. Is the temperature range the same for penetrant application and drying? Please explain.

53. Why is a coarse spray of water recommended for washing off excess penetrant and not a fine spray at a higher pressure?

54. In using a black light to inspect a part you discover that the intensity of the light at the surface of the part is only 700 microwatts per square centimeter when using an object-to-light distance of 16 inches, how do you correct this problem?

55. When checking for shallow discontinuities with a post-emulsified penetrant which is more important and why? Close attention to penetrant dwell time or emulsification time?

56. What is an acceptable emulsification time when using a lipophilic emulsifier?

57. Which situation would be more damaging and why, using more penetrant than is required or more developer than required?

58. The one thing that a person should learn is that penetrant testing can require an elaborate setup. How many stations would be required for the following penetrant system: Fluorescent, post-emulsified penetrant hydrophilic emulsifier/dry developer

59. How can you as a technician verify that the penetrant you use is LOX compatible?

PT HW 1 **Name: __________________**

1. Liquid penetrant can enter very fine cracks by:

   a. osmosis.
   b. seepage.
   c. capillary action.
   d. reverse flow.

2. Excellent wetting action of a penetrant is obtained when the contact angle (Theta) is:

   a. equal to alpha.
   b. less than 90 degrees.
   c. more than 180 degrees.
   d. equal to 2 times Pi divided by gamma.

3. What factors will affect the height that a liquid will rise in a tube under capillary action?

   a. surface tension of the liquid.
   b. contact angle.
   c. density of the liquid.
   d. radius of the capillary tube.
   e. all the preceding.

4. Which property of a liquid has very little effect on capillary use?

   a. Temperature.
   b. Viscosity.
   c. Wetting action.
   d. Density.

5. Penetrant is pulled from the discontinuity after the developer is applied by what action?

   a. Capillary (blotting action).
   b. Soak-up.
   c. Viscosity-pull.
   d. All the preceding.

6. In which process does the color of the penetrant not play an important role?

   a. Color-contrast.
   b. Visible-ye.
   c. Fluorescent.
   d. Color-sensitive.

7. What is another name for "black light"?
   a. Ultraviolet light.
   b. Dark light.
   c. Long light.
   d. Surface light.

8. List the three basic penetrant systems:

   1. ____

   2. ____

   3. ____

9. What is the function of the emulsifier for a Post-Emulsifiable penetrant system?

   a. Aids in reducing surface tension.
   b. Makes the penetrant soluble in water.
   c. Makes the defect look larger.
   d. Improves color contact.

10. Which system does not use an emulsifier?

   a. Solvent-removable.
   b. Water-washable.
   c. Post-Emulsifiable.
   d. No correct answer, all use an emulsifier.

PT HW 2 **Name: _______________**

1. Which type of emulsifier acts on the penetrant by detergent action?

    a. Hydrophilic.
    b. Oil-based.
    c. Lipophilic.
    d. All the preceding.

2. How many types of developers are there?

    a. Three.
    b. Four.
    c. Six.
    d. Two.

3. What is another term for nonaqueous developers?

    a. Water-soluble.
    b. Water-washable.
    c. Solvent-suspendible.
    d. Water suspendible.

4. Why are chlorinated solvents not recommended for solvent-suspendible developers?

    a. They are flammable.
    b. They are toxic.
    c. They are non-volatile.
    d. All the preceding.

5. Which type of developer would we use most effectively on rough surfaces?

    a. Hydrophilic.
    b. Lipophilic.
    c. Solvent-suspendible.
    d. Dry powder.

6. Which is the most sensitive of the major penetrant systems?

    a. Post-Emulsifiable fluorescent.
    b. Water-washable visible dye.
    c. Solvent-removable visible dye.
    d. High sensitive penetrant.

7. Without adequate pre-cleaning of the surface, which condition(s) may occur?

   a. Penetrant does not enter the flaw.
   b. Penetrant reacts with something already in discontinuity.
   c. Surface around discontinuity retains enough penetrant to mask a true indication.
   d. All the preceding.

8. What type of alloys are subject to delayed cracking if they are contacted by halogenated compounds?

   a. Mild alloy steel.
   b. Lead.
   c. Titanium.
   d. Stainless, aluminum.

9. The time penetrant remains on the part is called?

   a. Dwell time.
   b. Soak time.
   c. Test time.
   d. Inspection time.

10. What is the maximum recommended pressure for the rinsing water?

   a. 50 psi.
   b. 344.74 KPa.
   c. a and b.
   d. All the preceding.

PT QUIZ 1 **Name: __________________**

1. Which one of the following conditions will affect the rate and the extent a liquid penetrant will enter cracks, fissures, and other small openings.

   a. The hardness of the specimen being tested.
   b. The surface condition of the specimen being tested.
   c. The color of the penetrant.
   d. The conductivity of the specimen being tested.

2. A generally accepted method for removing excess non-water-washable penetrant is:

   a. repeatedly dipping the test specimen in a cleaner.
   b. soaking the test specimen in hot detergent water.
   c. blowing the excess penetrant off the surface of the part with compressed air.
   d. wiping and cautiously cleaning the test specimen with a cleaner-dampened cloth.

3. Which of the following discontinuities can be found by the penetrant test method?

   a. A surface crack.
   b. A subsurface crack.
   c. An internal inclusion.
   d. None of the above.

4. Which of the following is generally the more acceptable method for cleaning parts prior to penetrant testing?

   a. Sand blasting.
   b. Wire brushing.
   c. Grinding.
   d. Vapor degreasing.

5. Which of the following is not a generally accepted method for cleaning parts prior to penetrant testing?

   a. Vapor degreasing.
   b. Liquid solvent.
   c. Wire brushing.
   d. Alkaline cleaner.

6. Black light with a proper functioning filter in place used for fluorescent penetrant inspection can cause permanent damage to:

   a. human tissues.
   b. human eyes.
   c. human blood cells.
   d. None of the above.

7. When using a post-emulsification penetrant, it is necessary to apply the emulsifier:

   a. before applying the penetrant.
   b. after the water wash operation.
   c. after the dwell time has elapsed.
   d. after the development time has elapsed.

8. Usually, the most desirable method of removing excess water-washable penetrant after the dwell time is by:

   a. a low pressure coarse water spray.
   b. water and brush.
   c. a solid stream of water.
   d. water and clean rags.

9. Liquid penetrant testing is capable of detecting:

   a. Intergranular discontinuities.
   b. Discontinuities open to the surface.
   c. Subsurface discontinuities.
   d. all of the above.

10. The term used to define the tendency of certain liquids to penetrate into small openings such as cracks or fissures is:

   a. Saturation.
   b. Capillary action.
   c. Blotting.
   d. Wetting agent.

PT QUIZ 2 **Name: __________________**

1. Which of the following is an advantage of visible dye penetrant over fluorescent penetrants?

   a. Visible dye penetrants do not require black light.
   b. Visible dye penetrants are more sensitive than fluorescent penetrants.
   c. Visible dye penetrants are superior in penetrating characteristics.

2. The terms "dry, aqueous wet," and "nonaqueous wet" are used to describe three different types of:

   a. emulsifiers.
   b. cleaners.
   c. developers.
   d. penetrants.

3. When using solvent-removable penetrants, the excess penetrant may be removed by:

   a. dipping the part in solvent.
   b. spraying the part with water and a solvent.
   c. rubbing the part with a wet rag.
   d. wiping the part with a rag or cloth that has been dampened with solvent.

4. Which of the following is generally accepted as the most important pre-caution when using water-washable penetrant?

   a. Be sure that the part is washed thoroughly during the rinse operation.
   b. Be sure the recommended dwell time is not exceeded.
   c. Avoid over-rinsing the part.
   d. Avoid over-application of emulsifier.

5. Insufficient rinsing of fluorescent penetrants will result in:

   a. subsequent corrosion of the surface.
   b. difficulty in the application of developer.
   c. excessive bleed-out.
   d. excessive background fluorescence.

6. A good commercial penetrant should have a:

   a. low flash point.
   b. high flash point.
   c. medium flash point.
   d. flash point is not a factor to be considered.

7. A material which applied over the film of the penetrant on the surface of a part, mixes with the penetrant, and enables it to be washed off the surface is:

   a. an emulsifier.
   b. a penetrant.
   c. a developer.
   d. an isomer.

8. The speed with which a penetrant penetrates a surface flaw is influenced to the greatest extent by which of the following properties?

   a. Density.
   b. Surface tension and wetting ability.
   c. Viscosity.
   d. Relative weight.

9. Which of the following is not a form in which penetrant developer is commonly available?

   a. Dry developer.
   b. Non-aqueous developer.
   c. Wet developer.
   d. High viscosity developer.

10. Developer assists in the detection of the visible dye penetrant test indications by:

   a. providing a clean surface.
   b. providing a contrasting background.
   c. providing a dry surface.
   d. emulsifying the penetrant bleed-out.

PT QUIZ 3 **Name: _______________**

1. Generally, vapor degreasing is considered to be one of the best methods of preparing a part for liquid penetrant inspection because:

   a. it totally removes all surface contaminants.
   b. the solvent vapor removes all petroleum based materials.
   c. the method is easily adapted to virtually any size of the part.
   d. the solvent vapor removes all inorganic soils.

2. When removing excess post-emulsifiable penetrant in a production situation involving small irregularly shaped parts, one may use a:

   a. strong forceful spray.
   b. strong water blast.
   c. commercial solvent.
   d. hot water immersion.

3. The best method of drying after the application of a wet developer is normally:

   a. blotting the surface gently with absorptive paper toweling.
   b. allowing the part to dry slowly at or slightly above the ambient temperature.
   c. rapid drying with a normal room temperature air blast.
   d. rapid drying with circulating hot air at 170-225 degrees F.

4. Removal of residual penetrant or developer materials by a suitable post-cleaning technique is advantageous in which of the following cases?

   a. Where it could interfere with subsequent processes or with service.
   b. Where it could provide a contrasting background.
   c. Where it could assist in the emulsification of the penetrant bleed out.
   d. Where it could assist in the lattice structure breakdown.

5. A good penetrant must be:

   a. inert with respect to the materials being tested.
   b. highly viscous.
   c. highly volatile.
   d. an inorganic base liquid.

6. Which of the following functions does a developer perform?

   a. ~Blots~ the penetrant by drawing it out of discontinuities.
   b. Masks out non-relevant indications.
   c. Dries out the surface of the part.
   d. Provides a non-contrasting background.

7. If an indication reappears after the original developer has been removed and another coat is applied:

a. the discontinuity contains a reservoir of penetrant.
b. the discontinuity is probably shrinkage.
c. the discontinuity is most likely porosity.
d. the discontinuity is most likely a crack.

8. A partially welded forging lab would probably:

a. give no indication.
b. appear as a very thin, continuous line.
c. appear as a broad, continuous line.
d. appear as an intermittent line.

9. The forces generated by capillary, attraction cause a liquid to rise spontaneously in a capillary, tube. These forces are also involved in the:

a. entry of a liquid into a crack.
b. solubility of a liquid.
c. flash point of a liquid.
d. chemical inertness of a liquid.

10. The sensitivity of two penetrants for crack detection is best compared by:

a. using a hydrometer to measure specific gravity.
b. using cracked aluminum blocks.
c. measuring the contact angles in a wetting test.
d. the Meniscus test.

PT TEST **Name: ________________**

1. Which one of the following conditions will affect the rate and extent a liquid? Penetrant will enter cracks, fissures and other small openings?

   A. The hardness of the specimen being tested.
   B. The surface condition of the specimen being tested.
   C. The color of the penetrant.
   D. The conductivity of the specimen being tested.

2. Which of the following is a commonly used classification for penetrants?

   A. Post-emulsification penetrant.
   B. Nonferrous penetrant.
   C. Chemical etches penetrant.
   D. Nonaqueous penetrant.

3. Which of the following parts could not be tested by the liquid penetrant method?

   A. An iron casting.
   B. An aluminum forging.
   C. A part made from a porous material.
   D. A part made from a non-porous material.

4. Which of the following discontinuities can be found by the penetrant test method?

   A. A surface crack.
   B. A subsurface crack.
   C. An internal inclusion.
   D. None of the above.

5. Which of the following is generally the most acceptable method for cleaning parts prior to penetrant testing?

   A. Sand blasting.
   B. Wire brushing.
   C. Grinding.
   D. Vapor degreasing.

6. Which of the following is not a generally accepted method for cleaning parts prior to penetrant testing?

   A. Vapor degreasing.
   B. Liquid solvent.
   C. Wire brushing.
   D. Alkaline cleaner.

7. Black light used for fluorescent penetrant inspection can cause permanent damage to:

A. Human tissues.
B. Human eyes.
C. Human blood cells.
D. None of the above.

8. Sub-surface discontinuities can best be detected by:

A. The post-emulsification penetrant method.
B. The visible dye penetrant method.
C. The fluorescent, water-washable penetrant method.
D. None of the above will detect sub-surface discontinuities.

9. The first step in conducting a liquid penetrant test on a surface that has been painted is to:

A. Carefully apply the penetrant over the surface.
B. Completely remove the paint.
C. Thoroughly wash the surface with a detergent.
D. Wire brushes the surface to roughen the smooth surface coating of paint.

10. Which of the following discontinuities would be impossible to detect using a liquid penetrant test?

A. Forging lap.
B. Crater crack.
C. Grinding cracks.
D. Non-metallic internal inclusions.

11. When conducting a water washable liquid penetrant test, the developer is applied:

A. Immediately after the penetrant has been applied.
B. Immediately before the penetrant is applied.
C. After removal of the penetrant.
D. After removal of the emulsifier.

12. The term used to describe the action of the developer in soaking up the penetrant in a discontinuity, so as to cause the maximum bleed out of the liquid penetrant for increased contrast and sensitivity is known as:

A. Blotting.
B. Capillary action.
C. Concentration.
D. Attraction.

13. A black light lamp should not be used with a cracked filter or without the filter in place because of the harmful effects to the human eyes caused by ______ emitted from such a lamp.

A. Black light.
B. Ultraviolet light.
C. Infrared light.
D. None of the above.

14. The term used to define the period of time in which the test part is covered with penetrant is:

A. Waiting time.
B. Soak time (drain time).
C. Penetration time (dwell time).
D. Bleed-in time.

15. The most desirable method of removing excess water-washable penetrant after the necessary penetration time is by:

A. A coarse pressure water spray.
B. Water and brush.
C. A solid stream of water.
D. Water and clean rags.

16. Which of the following is not a characteristic that applied to liquid penetrant testing?

A. The surface condition of the test specimen will help determine the penetration time.
B. The penetration (dwell) time is normally 5 to 60 seconds depending on the type of discontinuity to be detected.
C. Sandblasting is not a recommended method for preparing a surface prior to a penetrant test.
D. Penetrant can be applied to a test specimen by dipping the specimen in a tank containing penetrant.

17. When conducting a fluorescent penetrant test, a commonly-used technique for assuring that the excess penetrant has been removed prior to the application of a developer is:

A. To blow compressed air over the surface.
B. To chemically etch the surface.
C. To blot the surface with absorbent paper.
D. To scan the surface with a black light.

18. Liquid penetrant testing is capable of detecting:

A. Intergranular discontinuities.
B. Surface discontinuities.
C. Subsurface discontinuities.
D. All of the above.

19. The term used to define the tendency of certain liquids to penetrate into small openings such as cracks or fissures is:

A. Saturation.
B. Capillary action.
C. Blotting.
D. Wetting agent.

20. The term "non-relevant indication: is used to describe certain types of penetrant testing indications. Which of the following would be typical" non-relevant indication an?

A. Indications due to part geometry or part design configurations.
B. Nonmagnetic indications.
C. Multiple indications.
D. Non-linear indications.

21. Which of the following are commonly accepted methods for applying penetrant?

A. Dipping the part in penetrant (dipping).
B. Pouring the penetrant over the test specimen (flowing).
C. Spraying the penetrant on the test specimen (spraying).
D. All of the above.

22. When removing excess penetrant from the surface of a test specimen:

A. The cleaning operation must not remove more than 10% of the penetrant from discontinuities.
B. Sufficient excess penetrant must be removed to eliminate a confusing background.
C. Wiping with a dry, absorbent cloth works equally well on smooth or rough surfaces.
D. The use of a solvent-saturated cloth is a common method of cleaning.

23. Which of the following is an advantage of color-contrast penetrants over fluorescent penetrants?

A. Color-contrast penetrants do not require a black light.
B. Color-contrast penetrants are more sensitive than fluorescent penetrants.
C. Color-contrast penetrants are superior in penetrating characteristics.
D. Color-contrast penetrants are not toxic while fluorescent penetrants are toxic.

24. The terms “dry”, “aqueous wet” and “non-aqueous wet” are used to describe three different types of:

A. Emulsifiers.
B. Cleaners.
C. Developers.
D. Penetrants.

25. Which of the following is the most-commonly used method for removing non-water-washable penetrant from the surface of a test specimen?

A. Dipping in a solvent.
B. Spraying.
C. Hand wiping.
D. Blowing.

26. When conducting a penetrant test, which of the following health precautions is not applicable?

A. Keep the work area clean.
B. Wash any penetrant from skin with soap and water as soon as possible.
C. Keep penetrant off clothes.
D. Wash any excess penetrant from skin using gasoline.

27. Before conducting a liquid penetrant test, it is important to ensure the surface of the part is free of:

A. Oil or grease.
B. Acids or chromates.
C. Traces of water.
D. All of the above.

28. Liquid penetrant indications at the interface of two materials that have been press fitted together are often called:

A. Discontinuity indications.
B. Defect indications.
C. Non-relevant indications.
D. Geometrical configurations.

29. When penetrant testing, the time period from developer application to inspection is often referred to as:

A. Emulsification time.
B. Development time.
C. Dwell time.
D. None of the above.

30. When conducting a penetrant test using fluorescent penetrant, black light equipment is required to:

A. Cause the penetrant to fluoresce.
B. To aid the normal capillary action characteristics of a penetrant.
C. To neutralize excess penetrant on the surface.
D. To decrease the surface tension of the part.

31. Which of the following discontinuities could produce a penetrant indication consisting of a series of aligned dots?

A. A tight crack.
B. A wide or gross crack.
C. An open seam.
D. Random porosity.

32. Which of the following discontinuities could be classified as a finishing discontinuity?

A. Fatigue crack.
B. Stress-corrosion crack.
C. Lamination.
D. Heat treat crack.

33. Which of the following discontinuities could be classified as a servicing discontinuity?

A. Fatigue crack.
B. Porosity.
C. Machining tear.
D. Lap.

34. Aluminum alloy test specimens that have been tested by the liquid penetrant method should be thoroughly cleaned after testing because:

A. The acid in the penetrant may cause severe corrosion.
B. The alkaline content of wet developers and most emulsifiers could result in surface pitting, particularly in moist atmospheres.
C. The toxic residue from the test will severely inhibit the application of paint on aluminum alloys.
D. A chemical reaction between the penetrant and aluminum could cause a fire because of internal combustion.

35. The reason it is difficult to reinspect a part that has been inspected using a liquid penetrant is:

A. The first inspection will leave an oily film over the surface.
B. The penetrant used during the second inspection will not be sufficiently viscous to perform the test.
C. The dried penetrant residue left in discontinuities may not readily dissolve and the retest may be misleading.
D. The indications from the first inspection will interfere with the indications from the second inspection.

36. Which of the following is a possible cause for false penetrant indications?

A. Excessive washing.
B. Inadequate application of developers.
C. Penetrant or part too cold during penetration time.
D. Lint or dirt.

37. Developer assists in the detection of penetrants retained in discontinuities by aiding the:

A. Post cleaning process.
B. Emulsification process.
C. Bleed-out process.
D. Drying process.

38. A term used to define defect is:

A. Any discontinuity with a volume greater than 1/8 cubic inches.
B. Any abnormal condition in a part.
C. Any change in the structure of a material.
D. A discontinuity, the size, shape, orientation, or location of which makes it detrimental to the useful services of the part in which it occurs.

39. Which of the following methods for applying developer is normally considered most effective? For large parts?

A. Spraying.
B. Swabbing.
C. Brushing.
D. Dipping.

40. Which of the methods listed below is most sensitive for detecting fine, tight surface cracks?

A. Visible dye, water-washable.
B. Visible dye, post emulsifiable.
C. Fluorescent, water-washable.
D. Fluorescent, post emulsifiable.

41. The maximum air temperature of hot air dryers used in a penetrant system should not exceed:

A. 100 ºF.
B. 150 ºF.
C. 200 ºF.
D. 250 ºF.

42. Fluorescent materials used in fluorescent penetrants respond most actively to radiant energy, of a wavelength of approximately:

A. 7,000 angstroms.
B. 250 KV
C. 3,650 angstroms.
D. 100 foot candles.

43. Which of the following is not an important property that all penetrants must possess?

A. Fluidity.
B. Viscosity.
C. Volatility.
D. Wet ability.

44. Which of the following is not an aid that will help minimize the chances of good inspector missing a penetrant indication?

A. A good white light should be provided when visible dye penetrants are used.
B. A suitable darkened booth should be provided when non-fluorescent penetrants are used.
C. When inspecting with black lights and fluorescent penetrants, discontinuity indications will be easier to see if the inspector wears yellow sunglasses.
D. The inspector should have an assistant to double-check each inspection.

45. Which of the following is not an advantage of water-washable fluorescent penetrant?

A. Discontinuity indications have more brilliance and are easier to see than are indications when non-fluorescent penetrant is used.
B. There are not intermediate steps between the end of dwell time and washing with water.
C. There is not critical emulsification time when using this penetrant.
D. This penetrant method will reliably find open or shallow discontinuities.

46. Which of the following discontinuities could be classified as a primary processing discontinuities often found in cast material?

A. Fatigue crack
B. Stress-corrosion crack
C. Porosity
D. Lack of penetration

47. The penetrant indication for a cold shut on the surface of a casting will be:

A. a dotted or smooth continuous line.
B. a cluster of small indications.
C. a rough deep indication.
D. a large bulbous indication.

48. When conducting a penetrant test, spherical indications on the surface of a part could be indicative of:

A. fatigue cracks.
B. porosity.
C. weld laps.
D. hot tears.

49. When using a black light to inspect a part the intensity at the surface of the part should be:

A. 100 foot candles
B. 800 microwatts per cm2
C. 60 lumens
D. 43 ergs/inch

50. A good commercial penetrant should have a:

A. low flash point
B. high flash point
C. medium flash point
D. flash point is not a factor to be considered

51. Which type of developer would we use most effective on rough surfaces?

A. hydrophilic
B. lipophilic
C. solvent-suspendible
D. dry powder

52. Emulsifier time:

A. is important but not normally critical.
B. is the time needed to rinse the emulsifier and excess penetrant from the surface.
C. is extremely important and will greatly affect test results.
D. should be as long as economically practical.

53. Water-washable liquid penetrants differ from post-emulsification penetrants in that water-washable penetrants:

A. can only be used on aluminum test specimens.
B. need not be removed from surfaces prior to development.
C. have a soapy base.
D. do not need the application of an emulsifier before rinsing.

54. Which of the following is not good practice when penetrant testing?

A. Applying emulsifier by dipping the part in emulsifier.
B. Applying developer by spraying the part with developer.
C. Removal of water-washable penetrant with a water spray.
D. applying emulsifier with a brush.

55. When penetrant testing Titanium alloys, the materials used in the penetrant system should not contain any constituent quantities of:

A. carbon or oil.
B. halogenated solvents.
C. emulsifier or oil.
D. fluorescent agent.

56. Which of the following discontinuities might be found in a welded fabrication?

A. Shrinkage
B. Lack of fusion
C. Seams
D. Laps

57. Which of the following discontinuities might be found in rolled bar stock?

A. Shrinkage
B. Bleed-out
C. Laps
D. Undercut

58. Which of the following discontinuities might be found in rolled plate?

A. Laminations
B. Shrinkage
C. Lack of fusion
D. Undercut

59. Which of the following is a discontinuity that might be found in a forging?

A. Shrinkage cracks
B. Laps
C. Cold shuts
D. Insufficient penetration

60. The prime purpose of the black light for fluorescent penetrant inspection is:

A. to magnify indications.
B. to make the indications visible.
C. to develop indications.
D. to speed up inspection.

61. Why is it advisable to have a black light installed at the wash station?

A. So that inspection can be done without drying parts.
B. To speed the bleeding of penetrants out of defects.
C. To check the effectiveness of the wash cycle.
D. To determine if parts have been covered with penetrant.

62. Wetting ability is measured by the

A. Specific gravity.
B. Density.
C. Contact angle.
D. Surface tension.

63. When inspecting using fluorescent penetrant methods, indications will appear as a:

A. Soft white glow against a gray background.
B. Brilliant yellow-green glow against a white background.
C. Brilliant yellow-green glow against a deep violet-blue background.
D. Bright yellow-green glow against a black background.

64. A penetrant that will spread over the surface of the test area in a smooth, even film despite a small amount of surface contamination is said to have:

A. Low viscosity.
B. High viscosity.
C. Wetting ability.
D. Low evaporation.

65. For post-emulsifiable penetrants, a good method for establishing emulsifying time is by:

A. Experimentation
B. The water drop-through test.
C. The water-tolerance test.
D. Using published book values.

NAME __________________

PT TEST

PT PART 2

1. Which of the following discontinuities could be classified as a primary processing discontinuities often found in cast material?

   A. Fatigue crack
   B. Stress-corrosion crack
   C. Porosity
   D. Lack of penetration

2. The penetrant indication for a cold shut on the surface of a casting will be:

   A. a dotted or smooth continuous line.
   B. a cluster of small indications.
   C. a rough deep indication.
   D. a large bulbous indication.

3. When conducting a penetrant test, spherical indications on the surface of a part could be indicative of:

   A. fatigue cracks.
   B. porosity.
   C. weld laps.
   D. hot tears.

4. Which of the following is a possible cause for false penetrant indications?

   A. Excessive washing
   B. Inadequate application of developers
   C. Penetrant or part too cold during penetration time
   D. Lint or dirt

5. Developer assists in the detection of penetrants retained in discontinuities by aiding the:

   A. post-cleaning process
   B. emulsification process
   C. bleed-out process
   D. drying process

6. Fluorescent materials used in fluorescent penetrants respond most actively to radiant energy, of a wavelength of approximately:

   A. 7,000 Angstroms.
   B. 250 KV
   C. 3,650 Angstroms.
   D. 100 foot candles.

7. Emulsifier time:

   A. is important but not normally critical.
   B. is the time needed to rinse the emulsifier and excess penetrant from the surface.
   C. is extremely important and will greatly affect test results.
   D. should be as long as economically practical.

8. Water-washable liquid penetrants differ from post-emulsification penetrants in that water-washable penetrants:

   A. can only be used on aluminum test specimens.
   B. need not be removed from surfaces prior to development.
   C. have a soapy base.
   D. do not need the application of an emulsifier before rinsing.

9. Which of the following is not good practice when penetrant testing?

   A. Applying emulsifier by dipping the part in emulsifier.
   B. Applying developer by spraying the part with developer.
   C. Removal of water-washable penetrant with a water spray.
   D. applying emulsifier with a brush.

10. When penetrant testing Titanium alloys, the materials used in the penetrant system should not contain any constituent quantities of:

   A. carbon or oil.
   B. halogenated solvents.
   C. emulsifier or oil.
   D. fluorescent agent.

11. Which of the following discontinuities might be found in a welded fabrication?

   A. Shrinkage
   B. Lack of fusion
   C. Seams
   D. Laps

12. Which of the following discontinuities might be found in rolled bar stock?

A. Shrinkage
B. Bleed-out
C. Laps
D. Undercut

13. Which of the following discontinuities might be found in rolled plate?

A. Laminations
B. Shrinkage
C. Lack of fusion
D. Undercut

14. Which of the following is a discontinuity that might be found in a forging?

A. Shrinkage cracks
B. Laps
C. Cold shuts
D. Insufficient penetration

15. The prime purpose of the black light for fluorescent penetrant inspection is:

A. to magnify indications.
B. to make the indications visible.
C. to develop indications.
D. to speed up inspection.

16. Why is it advisable to have a black light installed at the wash station?

A. So that inspection can be done without drying parts.
B. To speed the bleeding of penetrants out of defects.
C. To check the effectiveness of the wash cycle.
D. To determine if parts have been covered with penetrant.

17. Wetting ability is measured by the

A. specific gravity.
B. density.
C. contact angle.
D. surface tension.

18. When inspecting using fluorescent penetrant methods, indications will appear as a:

A. soft white glow against a gray background.
B. brilliant yellow-green glow against a white background.
C. brilliant yellow-green glow against a deep violet-blue background.
D. bright yellow-green glow against a black background.

19. A penetrant that will spread over the surface of the test area in a smooth, even film despite a small amount of surface contamination is said to have:

A. low viscosity.
B. high viscosity.
C. wetting ability.
D. low evaporation.

20. For post-emulsifiable penetrants, a good method for establishing emulsifying time is by:

A. experimentation
B. the water drop-through test.
C. the water-tolerance test.
D. using published book values.

Liquid Penetrant Testing
ASME
Examination Procedure
PT- 1

Liquid Penetrant Testing
ASME Examination Procedure Testing

TABLE OF CONTENTS

Liquid Penetrant Testing
ASME Examination Procedure

1.0 PURPOSE AND SCOPE

1.1. This procedure establishes the process, requirements for Liquid Penetrant Examination.

1.2. This procedure will be followed by PCC when a customer requests Liquid Penetrant Examination to be performed in accordance with ASME Section V Article 6.

1.3. The frequency of inspection will be as required by purchase orders, specifications, drawings, codes, or other data as required by the customer.

2.0 REFERENCES

2.1. ASME Boiler and Pressure Vessel Code, Section V, 1983 edition, 1989 addenda.

3.0 QUALIFICATION OF PERSONNEL

3.1. Personnel performing Liquid Penetrant Examination will be certified to at least level I in accordance with PCC Qualification and Certification of Nondestructive Examination Personnel Procedure QC-001.

3.2. PT Level I, ll, and lll personnel may perform all operations necessary in accordance with this procedure to process the objects being examined.

3.3. Interpretation and evaluation of liquid penetrant examination results will be accomplished by personnel certified as PT Level ll or lll

4.0 PENETRANT MATERIAL CERTIFICATION

4.1. Intermixing of penetrant materials from different families is not permitted.

4.2. A certification of contaminant content for all liquid penetrant materials used on nickel base alloys, austenitic stainless steels, and titanium will be obtained.

4.2.1. These certifications will include the penetrant manufacturers' batch numbers and the test results obtained according to 1) and 2) below:

(1) When examining nickel base alloys, all materials must be analyzed individually for sulfur content as follows:

(a) An individual sample of the penetrant materials with exception of cleaners will be prepared for analysis by heating 50 g of the material in a 150 mm nominal diameter glass Petri dish, at a temperature of 194^0 F to 212^0 F for 60 min.

(b) Analysis of the residue will be as follows:

(1) If the residue is less than 0.0025 g, the material is acceptable without further analysis.

(2) If the residue is 0.0025 g or more, the procedure shown in 4.2.1)(a) will be repeated and the residue analyzed in accordance with ASTM 0 129 or ASTM D tS52.

(3) Alternately, the material may be decomposed in accordance with ASTM D 123 and analyzed in accordance with ASTM D 516 Method B.

(4) The sulfur content must not exceed 1% of the residue by weight.

(c) An individual sample of, cleaner/remover material must be prepared for analysis by heating 100 g of the material in a 150 mm nominal diameter glass Petri dish at a temperature of 194^0 F to 212^0 F for 60 min.

(d) Analysis of the residue will be as follows:

(1) If the residue is less than 0.005 g, the material is acceptable without further analysis.

(2) If the residue is 0.005 ~ or more, the procedure shown in 4,2.1.2)(c) will be repeated and the residue analyzed in accordance with ASTM D 129 or SE-165 for chlorine and SE-165 Annex 3 for fluorine.

(3) The chlorine plus fluorine content must not exceed 1% of the residue by weight.

5.0 PREPARATION FOR EXAMINATION

5.1. In general, satisfactory results may be obtained when the surface of the part is in the as welded as-roiled, as-cast, or as-forged condition.

5.1.1. Surface preparation or conditioning by grinding or machining will be required when there is a possibility that surface irregularities would otherwise mask the indications of unacceptable discontinuities.

5.1.2. Abrasive cleaning (blasting, sanding) barrel and vibratory finishing, buffing and burnishing, impregnation or plating, or shot peening will not be allowed.

1) Some sandblasting will be considered acceptable if it is proven to not obscure discontinuities.

5.2. Prior to all liquid penetrant examination's, the surface to be examined and all adjacent areas within at least 1in. will be dry and free of all dirt, grease, lint, scale, melting flux, weld spatter, oil' and other extraneous matter that could obscure surface openings or otherwise interfere with the examination.

5.3. Typical cleaning agents which may be used are detergents, organic solvents' descaling solutions, and paint removers.

5 3.1. Degreasing and ultrasonic cleaning methods may also be used.

5.3.2. Cleaning solvents must meet the requirements of 4.2.1.

5.4. After cleaning, drying of the surfaces to be examined will be accomplished by normal evaporation or with forced hot air, as appropriate.

5.4.1. A minimum, of two minutes evaporation time will be allowed, prior to application of the penetrant, to assure the surface to be examined is dry.

5.5. The temperature of the penetrant and the surface of the material to be examined must not be below 60^0 F nor above 125^0 F during the penetrant process' or the procedure (application technique) must be qualified in accordance with Section 10 of this procedure, for the nonstandard temperature.

5.5.1. Local heating and cooling is permitted provided the temperature of the surface being examined is maintained in the range of 60^0 F to 125^0F during the examination.

6.0 COLOR CONTRAST SOLVENT REMOVABLE PENETRANT

6.1. This section establishes the method for examining parts and materials using the Color Contrast Solvent Removable Penetrant Process. Any equipment or material listed In this section may be replaced with an equivalent if the PT Level III approves and documents the change.

6.2. Color contrast solvent removable penetrant materials will be:

6.2.1. Magnaflux Spotcheck Penetrant SKL+HF/S.

6.2.2. Magnaflux Spotcheck Cleaner/Remover SKC-NF or SKC-S.

6.2.3. Magnaflux Spotcheck Developer SKD-NF or SKD-S

6.3. The "Penetrant" will be applied by brushing or spraying.

6.3.1 The penetration dwell time must be a minimum of 10 minutes.

1) If conditions dictate, the dwell time may be increased as required to a maximum of 60 minutes.

2) In any event, the surface being examined must be kept completely wet for the full duration of the penetration time.

3) Should the penetrant material thicken, congeal, or dry, the surface being examined must be re-cleaned and the penetrant must be reapplied.

6.4. Drying prior to developing must be accomplished by allowing a minimum of 5 minutes for normal evaporation.

1) Blotting, wiping, or force air may be used to aid drying.

6.5. The developer must be applied after drying (5 minutes) and not more than 10 minutes following the penetrant removal operation.

6.5.1. The developer must be of the pressurized spray can type and must be thoroughly agitated prior to application.

6.5.2. The developer will be sprayed on in a thin uniform coating.

6.5.3. The examiner will observe the surface during the application of the developer in order to detect the nature of certain indications, which might tend to bleed out profusely.

1) White light at the surface being examined will be adequate to distinguish the contrast between the developer and any penetrant bleed out.

6.5.4. Final interpretation will be made after allowing a development time of at least 7 minutes and not more than 30 minutes.

1) Development time starts as soon as the wet developer coating is dry.

7.0 COLOR CONTRAST WATER-WASHABLE PENETRANT

7.1. This section establishes the method for examining parts and materials using the Color Contrast Water-Washable Penetrant Process. Any equipment or material listed in this section may be replaced with an equivalent if the PT Level III approves and documents the change.

7.2. Color contrast water-washable materials will be:

7.2.1. Magnaflux Spotcheck Penetrant SKL-WP.

7.2.2. Magnaflux Spotcheck Cleaner/Remover SKGNF or SKC-S.

7.2.3. Magnaflux Spotcheck Developer SKD-NF or SKD-S.

7.3. The "Penetrant" will be applied by dipping, brushing, or spraying.

7.3.1. The penetration dwell time must be a minimum of 10 minutes.

1) If conditions dictate, the dwell time may be increased as required to a maximum of 60 minutes.

2) In any event, the surface being examined must be kept completely wet for the full duration of the penetration time.

3) Should the penetrant material thicken, congeal, or dry, the surface being examined must be re-cleaned and the penetrant must be reapplied.

7.4. Excess penetrant, in so far as possible, will be removed by a coarse water spray.

7.4.1. The water pressure must not exceed 50 psi, and the water temperature will be a minimum of 60^0F and not exceed 110^0F.

1) Care must be exercised to limit the removal of penetrant from any discontinuity to as little as possible.

7.4.2. Surface drying prior to developing will be accomplished by blotting with paper towels or clean lint free cloths, or circulating warm air, provided the temperature of the surface is not raised above 125^0F'

7.5. The developer must be applied within 10 minutes following the surface drying operation.

7.5.1. The developer must be of the pressurized spray can type and must be thoroughly agitated immediately prior to application.

7.5.2. The developer will be sprayed on in a thin uniform coating.

7.5.3. The examiner will observe the surface during the application of the developer in order to detect the nature of certain indications, which might tend to bleed out profusely.

1) White light at the surface being examined will be adequate to distinguish the contrast between the developer and any penetrant bleed out.

7.5.4. Final interpretation will be made after allowing a development: time of at least 7 minutes and not more than 30 minutes.

1) Development time starts as soon as the wet developer coating is dry.

8.0 FLUORESCENT SOLVENT REMOVABLE PENETRANT

8.1. This section establishes the method for examining parts and materials using the Fluorescent Solvent Removable Penetrant Process. Any equipment or material listed in this section may be replaced with an equivalent if the PT Level III approves and documents the change.

8.2. Fluorescent solvent removable penetrant materials will be:

8.2.1 Magnaflux Zyglo Penetrant ZL-22C.

8.2.2. Magnaflux Spoicheck Cieaner/Remover SKC-NF or SKC-S.

8.2.3. Magnaflux Zyglo Developer ZP-9E or ZP-9F.

8.3. The "Penetrant" will be applied by brushing or spraying.

8.3.1. The penetration dwell time must be a minimum of 10 minutes.

1) If conditions dictate, the dwell time may be increased as required to a maximum of 60 minutes.

2) In any event, the surface being examined must be kept completely wet for the full duration of the penetration time.

3) Should the penetrant material thicken; congeal, or dry, the surface being examined must be re-cleaned and the penetrant must be reapplied.

8.4. Excess penetrant, insofar as possible, will be removed by wiping with clean, dry cloths under a black light.

8.4.1. A clean dry cloth will then be moistened with ZL-10A o. ZL-1OB remover and the surface will be wiped lightly.

1) This operation will be repeated until most traces of penetrant have been removed.

2) Care must be exercised to limit the removal of penetrant form any discontinuity to as little as possible.

3) Flushing the surface with solvent following the application of the penetrant and prior to developing is prohibited.

8.4.2. Drying prior to developing must be accomplished by allowing a minimum of 5 minutes for normal evaporation.

1) Blotting' wiping, or force air may be used to aid drying.

8.5. The developer must be applied after drying (5 minutes) and not more than 10 minutes following the penetrant removal operation.

8.5.1. The developer must be of the pressurized spray can type and must be thoroughly agitated prior to application.

8.5.2. The developer will be sprayed on in a thin uniform coating.

8.5.3. The examination will be performed in a darkened area.

1) Examiners working in darkened areas will allow 5 minutes for conditioning each time the darkened area is entered from white light or each time the examiner looks into the direct beam of the black light.

8.5.4. The examination area will be equipped with a Magnaflux Corporation, Model ZB-23A or equivalent black light and a white Light source suitable for visual evaluation of discontinuities.

1) A minimum of 10 minutes for black light warm-up (upon initial start-up) will be allowed before the black light is used in examinations.

(a) Dark adaption to a 20% target on the Ardrox, Inc. Cat. #42244g ,inspectability Scale may be used in lieu of the above requirements.

2) The examiner will maintain a distance between the black light and the part being examined of no greater than 15".

3) black light will have a minimum intensity of 800 microwatts/cm^2 at 15" and will be checked, with a Magnaflux Corporation Model DM 365X Black light meter or equivalent which is calibrated annually, and recorded every eight hours, or whenever the work area is changed.

8.5.5. Examiners will not wear eye glasses with tinted lenses (sunglasses) or eyes glasses, which change color in sunlight during examinations.

8.5.6. The examiner will observe the surface under black light during the application of the developer in order to detect the nature of certain indications, which might tend to bleed out profusely.

8.5.7. Final interpretation will be made after allowing a development time of 7 to 30 minutes.

1) Development time starts as soon as the wet developer coating is dry.

9.0 FLUORESCENT WATER-WASHABLE PENETRANT

9.1. This section establishes the method for examining parts and materials using the Fluorescent Water-Washable Penetrant Process. Any equipment or material listed in this section may be replaced with an equivalent if the PT Level III approves and documents the change.

9.2. Fluorescent Water-Washable Penetrant material will be:

9.2.1. Magneflux Zyglo Penetrant ZL-60C.

9.2.2. Magnaflux Zyglo Developer ZP-5E or ZP-9F.

9.3. The "Penetrant" will be applied by dipping, brushing, or spraying.

9.3.1. The penetration dwell time must be a minimum of 10 minutes.

1) If conditions dictate, the dwell time may be increased as required to a maximum of 60 minutes.

2) in any event, the surface being examined must be kept completely wet for the full duration of the penetration time.

3) Should the penetrant material thicken; congeal or dry, the surface being examined must be re-cleaned and the penetrant must be reapplied.

9.4 Excess penetrant insofar as possible, will be, removed by coarse water spray under a black.

9.4.1. The water pressure must not exceed 50 psi, and the water temperature will be a minimum of 60^0 F and not exceed 110^0 F

1) Care must be exercised to limit the removal of penetrant from any discontinuity to as little as possible.

9.4 2. Surface drying prior to developing will be accomplished by blotting with paper towels or clean lint-free cloths, or circulating warm air, provided the temperature of the surface is not raised above 125^0 F.

9.5 The developer must be applied within 10 minutes following the penetrant removal operation.

9.5.1. The developer must be of the pressurized spray can type and must be thoroughly agitated prior to application.

9.5.2. The developer will be sprayed on in a thin, uniform layer.

9 5.3. The examination will be performed, in a darkened area.

1) Examiners working in darkened areas will allow 5 minutes for conditioning each time that darkened area is entered from white light or each time the examiner into the direct beam of the black light.

(a) Dark adaption to a 20%, target on the Ardrox, Inc Cat #422449 inspectability scale may be use in lieu of the above requirements

9.5.4. The examination area will be equipped with a Magnaflux Corporation, Model ZB-23A or equivalent black light and a white light source suitable for visual evaluation of discontinuities.

1) A minimum of 5 minutes for black, light warm-up (upon initial start-up) will be allowed before the black light is used in examinations.

2) The examiner will maintain a distance between the black light and the part being examined of no greater than 15".

3) The black light will have a minimum intensity of 800 microwatts/cm ^{2}at 15" and will be checked, with a Magnaflux Corporation Model DM 365X Black light meter or equivalent which is calibrated annually, and recorded every eight hours, or whenever the work area is changed.

9.5.5. Examiners will not wear shaded (sun) glasses or eyeglasses, which change color in sunlight during examinations.

9.5.6. The examiner will observe the surface under black light during the application of the developer in order to detect the nature of certain indications, which might tend to bleed out profusely.

9.5.7. Final interpretation will be made after allowing a development time of 7 to 30 minutes.

1) Development time starts as soon as the wet developer coating is dry.

10.0 PROCEDURE QUALIFICATION FOR NONSTANDARD TEMPERATURES

10.1. When it is not practical to conduct a liquid penetrant examination within the temperature range of 60^0 F to 125^0F, the examination procedure &the proposed lower or higher temperature range requires qualification.

10.1.1. The qualification of a nonstandard temperature requires the use of a quench cracked aluminum block, which is described in ASME Section V, Article 6, and is designated as a liquid penetrant comparator block.

1) For use with this procedure, the liquid penetrant comparator block will be cut in halt and one-half will be designated block A", and the other, block "B".

10.1.2 Qualification of a liquid penetrant examination for use at temperature of less than 60^0 F will be accomplished as follows:

1) The proposed procedure will be applied to block ,'B,' after the block and all penetrant materials have been cooled and held at the proposed examination temperature until the comparison is completed.

2) The standard temperature procedure as described in this procedure will be applied to block “A" in the 60^0F to 125^0 temperature range.

3) Both block “A” and “B” will be processed at the same time so that the indications of the cracks in the two blocks can be compared at the completion of the development time for both

4) If the indications obtained under the proposed conditions on block "B" are essentially the same as obtained on block “A” during the examination at 60^0F to 125^0F, the proposed procedure will be considered qualified for use.

5) A procedure qualified at a temperature lower than 60^0 F will be qualified from that temperature to 60^0 F.

6) All the proposed conditions of the nonstandard low temperature procedure will be documented, along with the results of the comparison, and the nonstandard low temperature procedure will be attached to this procedure for use when required.

10.1.3. Qualification of a liquid penetrant examination for use at temperature above 125^0 F will be accomplished as follows:

1) The proposed procedure will be applied to block "B" after the block and all penetrant materials have been heated and held at the proposed examination temperature until the comparison is completed.

2) The standard temperature procedure as described in this procedure will be applied to block "A" in the 60^0 F to 125^0 F temperature range.

3) Both block "A" and "B" will be processed at the same time so that the indications of the cracks in the two blocks can be compared at the completion of the development time for both.

4) If the indications obtained under the proposed conditions on block "B" are essentially the same as obtained on block "A" during the examination at 60^0F to 125^0F, the proposed procedure will be considered qualified for use.

5) To qualify a procedure for temperatures above 125^0F, the upper and lower temperature limits will be established and the procedure will be qualified at these temperatures.

6) All the proposed conditions of the nonstandard high temperature procedure will be documented, along with the results of this comparison, and the nonstandard high temperature procedure will be attached to this procedure for use when required.

11.0 EVALUATION OF INDICATIONS

11.1. Mechanical discontinuities at the surface will be indicated by bleeding out of the penetrant; however localized surface imperfections, such as may occur from machining marks, or surface conditions, may produce similar indications which are non-relevant to the detection of unacceptable discontinuities.

11.2. Any indication which is believed to be non-relevant must be regarded as a defect and will be further examined to verify whether or not actual defects are present.

11.2.1. Visual examination or another examination method may be used for verification of non-relevant indications. `.

11.2.2. Surface conditioning may precede the reexamination.

11.2.3 Non-relevant indications and broad areas of pigmentation which would mask indications of defects are unacceptable.

11.3. Relevant indications are indications which result from mechanical discontinuities.

11.3.1. Linear indications are indications for which the length is more than three times the width.

11.3.2. Rounded indications are indications which are circular or elliptical with the length less than three times the width.

11.3.3. An indication of a discontinuity may be larger than the discontinuity that causes it; however, the size of the indication and not the size of the discontinuity is the basis of acceptance or rejection.

11.4. All indications will be evaluated in terms of the appropriate acceptance standards (paragraph 13.0).

11.5. A Liquid Penetrant Examination Report will be used to record examination results.

11.5.1. The customer will be provided with a copy of this report which will include as a minimum:

1) customer name, contract or job number, and report date;

2) signature and certification level of penetrant inspector;

3) vessel, tank, part, or weld number;

4) extent of examination;

5) type of pre- and post-cleaning material, penetrant, penetrant remover and developer used;

6) dwell time and penetrant or surface temperature if outside 60^0 F to 125^0 F range;

7) development time;

8) interpretation of each penetrant indication noting relevant and significant non-relevant indications;

9) evaluation of each penetrant indication noting acceptance or rejection;

10) reference to this procedure and the appropriate acceptance standards.

12.0 POST-EXAMINATION CLEANING

12.1. All components having been examined by the liquid penetrant method will be thoroughly cleaned by wiping with dry cloths and then with solvent dampened cloths.

12.2. For examinations using fluorescent penetrant materials the surface will be inspected with a black light to verify the effectiveness of the cleaning.

13.0 ACCEPTANCE STANDARDS

13.1. The acceptance standards will be as stated in the referencing code.

13.1.1. The edition of the code used for acceptance will be the latest issue in affect at the time of the evaluation of the penetrant results or the edition specified by the customer.

13.2. performing penetrant evaluations, the PT Level ll or lll will have available during evaluation a copy of the acceptance standard from the referencing code available for reference.

PCC
LIQUID PENETRANT TESTING
LAB 1

OBJECTIVE:

To familiarize the student, with the procedures and application of Liquid Penetrant inspection using the information and data learned in class. Visible, solvent removable penetrants will be used.

PROCDURES:

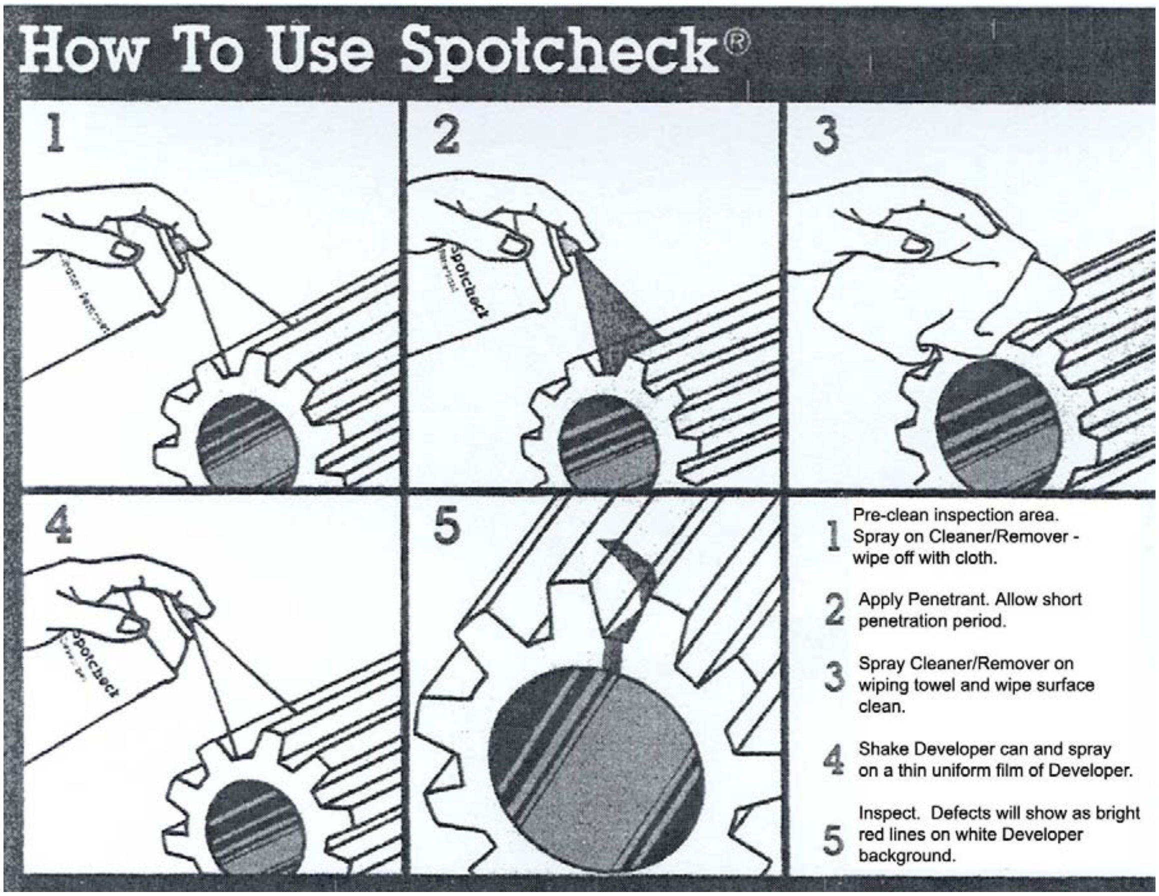
1. The instructor will provide a number of samples to be inspected. The student must decide the best way to test the part.

2. Students may work in groups of two or as individuals.

3. At least one defect must be located for each lab. May require inspection of more than one sample.

4. Each student must write up a complete report-containing lab 1. Use provided form Student should use one of the discussed methods to preserve indications.

5. Each student should be able to use any and all equipment as discussed or demonstrated in class.


How To Use Spotcheck®
1
2
Spotcheck
3
4
Spotcheck
5
1 Pre-clean inspection area. Spray on Cleaner/Remover - wipe off with cloth.
2 Apply Penetrant. Allow short penetration period.
3 Spray Cleaner/Remover on wiping towel and wipe surface clean.
4 Shake Developer can and spray on a thin uniform film of Developer.
5 Inspect. Defects will show as bright red lines on white Developer background.

PCC
LIQUID PENETRANT TESTING
LAB 2

OBJECTIVE:

To familiarize the student, with the procedures and application of Liquid Penetrant inspection using the information and data learned in class. Florescent, solvent removable penetrants will be used.

PROCDURES:

1. The instructor will provide a number of samples to be inspected. The student must decide the best way to test the part.

2. Students may work in groups of two or as individuals.

3. At least one defect must be located for each lab. May require inspecting more than one sample.

4. Each student must write up a complete report-containing lab 2. Use provided forms. Student should use one of the discussed methods to preserve indications.

5. Each student should be able to use any and all equipment as discussed or demonstrated in class.