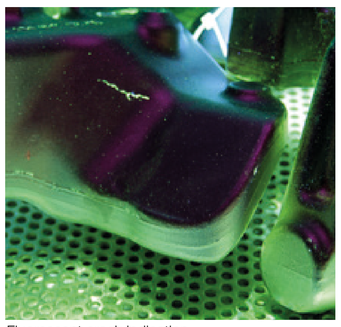
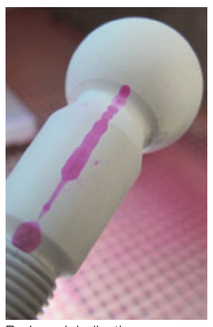
Basic Knowledge **PENETRANT TESTING**

PRINCIPLE

Penetration testing is used to detect surface defects in a wide range of materials.

In addition to metals, this also includes materials that are sometimes difficult to test, such as plastics and ceramics.
A distinction is made between dye penetrant testing with (in most cases) red-dyed testing agents and fluorescent penetration testing. The former is often used in individual component testing, usually with spray cans.
Fluorescent penetrant testing is the predominant method used in series production. This method can also be used to detect finer defects, but it is more complex (darkening, UV lighting, etc.).


Fluorescent crack indication


Red crack indication

In addition to oil-based testing media, water- and surfactant-based penetrants are also being used increasingly.
In some cases, this eliminates the need for costly wastewater treatment facilities, as these testing media can often be discharged directly into the sewer system after receiving official approval.

As a general rule, the testing equipment used must be compatible with each other and with the material being tested.

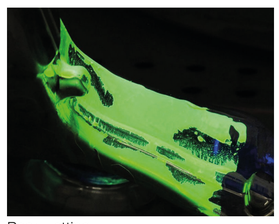
Areas of application and typical test components
- Aviation industry (e. g. turbine blades, wheels)
- Automotive industry (e. g. hub carriers, steering knuckles)
- Railway vehicles (e. g. engine casing)
- Mechanical engineering (e. g. pipelines)
- Ship construction (e. g. ship propellers)
- Nuclear reactors (e. g. valves, pump casing)
- Special materials (e. g. ceramics, titanium)
- Healthcare (e. g. implants)
- Container construction (e. g. food tanks, pipes)
- Foundry (e. g. fixtures, gear wheels)
- Welding technology (e. g. welded seams)

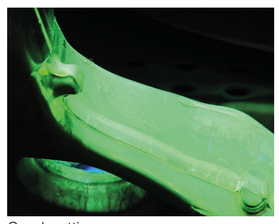
Application for
- Alloyed and unalloyed steels
- Non-ferrous metals
- Plating
- Steel, grey and malleable cast iron
- Welds
- Steatite
- Plastics
- Ceramics

Typical flaw indications
- Cold cracks
- Hot cracks
- Grinding cracks
- Shells
- Laminations
- Pores
- Clusters of pores
- Spongy structure
- Stress corrosion cracking

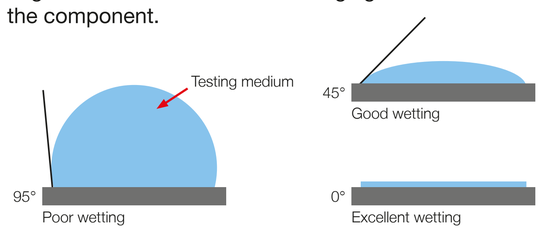
PROPERTIES OF TESTING MEDIA

Wetting behaviour
refers to the property of a liquid to spread over a surface.

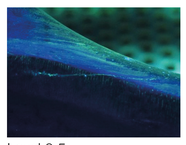

Poor wetting

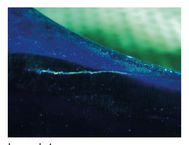

Good wetting

▶ IMPORTANT It is essential for penetrants that a small contact angle is formed between the testing agent and the surface of the component.



Sensitivity
refers to the indication capability of a penetrant.


Level 0.5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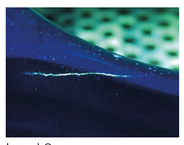
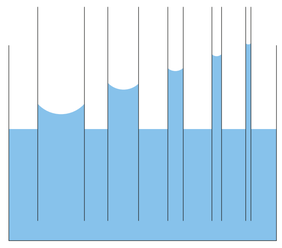

Level 3

▶ IMPORTANT It is essential to note that the sensitivity levels of the various standards are not comparable with one another, as different acceptance criteria are applied.

Viscosity
refers to the property of a liquid that affects its flow behaviour.

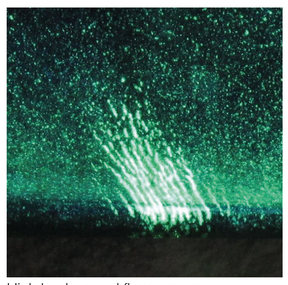
▶ IMPORTANT Low viscosity is essential for penetrating media, as this increases the flow rate. The result: faster penetration and less carryover.

Capillary action
refers to the ability of a liquid to ascend in a narrow tube.



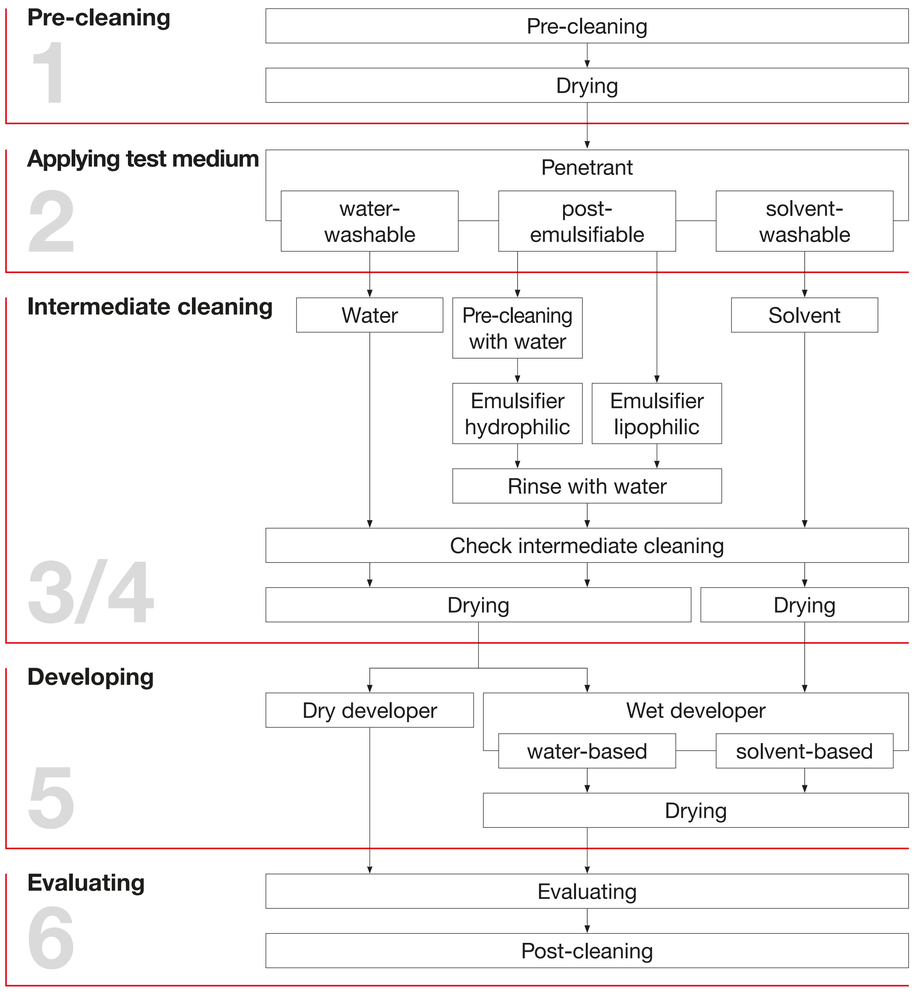
▶ IMPORTANT A key requirement for penetrating media is a high degree of capillary action.

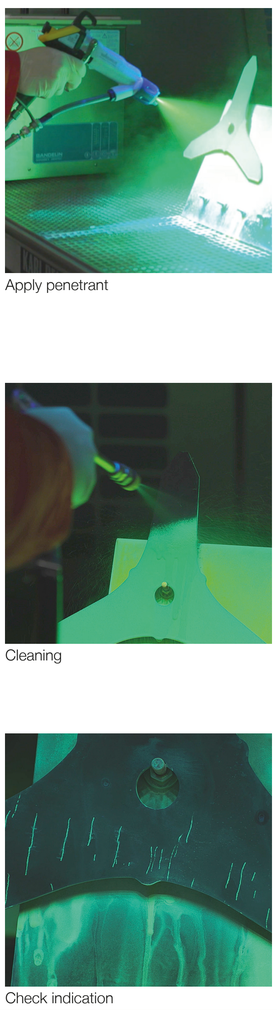
Wash-off behaviour
refers to the property of a penetrant that has a significant effect on the contrast between the indication and the background. The better the wash-off behaviour, the better the contrast, although overwashing must be prevented.


High background fluorescence


Low background fluorescence

TEST PROCEDURE



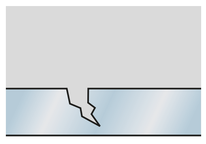

Apply penetrant

Cleaning

Check indication

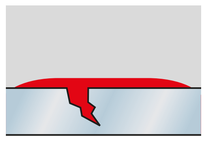
IMPORTANT PROCEDURAL STEPS IN DETAIL

1. Pre-cleaning
Common methods:
- Cleaning with solvents
- Cleaning with surfactants
- Steam degreasing
- Pickling (acid or alkaline)
- Electrical cleaning
- Ultrasonic cleaning
- Combination of these methods


After pre-cleaning, the crack is open to the surface and filled only with air.

1

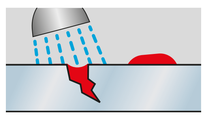
2. Applying the testing medium
Application of the penetrant by:
- Spraying
- Immersion
- Brushing
- Pouring over


After the penetrant application and the penetration time, the crack is filled as completely as possible with penetrant.

2

3. Intermediate cleaning
The cleaning step is performed by:
- Water
- Emulsifier
- Solvent
  (wipe the surface with a solvent-damped cloth)

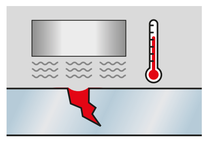
▶ ATTENTION!
Do not spray solvents for intermediate cleaning!


After intermediate cleaning, the penetrant should remain as completely as possible in the crack, but not on the surface.

3

4. Drying
Common methods:
- Air drying
- Hand-held dryer
- Drying oven

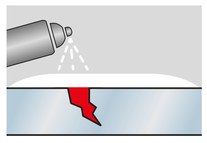
▶ ATTENTION!
The temperature of the component must not exceed 50 °C!


After this step, the area to be tested must be completely dry and free of any residual liquid.

4

5. Applying the developer
Possible variations:
- Solvent-based wet developer (spraying)
- Water-based wet developer (immersion)
- Dry developer

▶ ATTENTION!
Dry developer only for fluorescent penetrants!


Spray the developer on very thinly, just enough to create a white background.

5

6. Evaluation
Common methods:
- Visual inspection
- Inspection using optical aids (e. g. magnifying glass)


The indication appears wider than the actual inhomogeneity, as the testing medium 'bleeds' into the developer layer.

6

TESTING MEDIA AND ACCESSORIES

There is an extensive range of tools and accessories available for penetrant testing.

Reference test blocks are used to check the indication capability of a testing media system both during manufacture and at the user's site. The user must carry out the inspection on the reference test block in the same way as it is inspected on the object. The inspection is usually carried out before penetrant testing commences, but can also be executed at the beginning, middle, and end of a shift. The reference test block to be used and the testing interval are specified in the relevant standards and specifications.

Reference test block according to DIN EN ISO 3452-3 and fluorescent penetrant KD-CHECK FP-WB-2

UV light is required for fluorescent penetrants. These special lamps with a wavelength in the range of 365 nm are available in various designs.
In addition to hand-held lamps, large-area lamps are in use, both with energy-efficient LED technology.

Test stations and systems from KARL DEUTSCH enable users to test both individual parts and large series with high quantities in a standard-compliant and reproducible manner. The systems range from manually operated stations to linked, fully automatic systems with multiple transport lines. In addition to increased testing reliability, safety-related aspects are also taken into account.

STANDARDS AND DIRECTIVES

Standards specifically in Germany

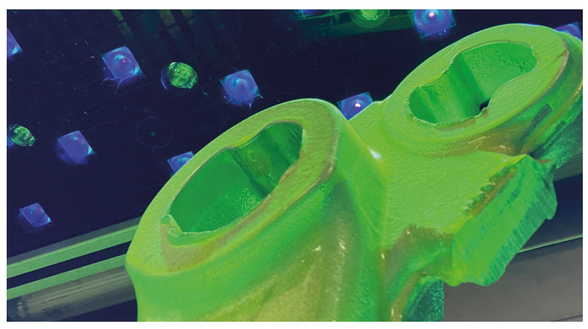
Standard	Designation
DGZfP-EM 1	Guideline on the visual ability of testing personnel for NDT surface testing methods
DGZfP-EM 6	Information sheet on viewing stations for fluorescent testing with magnetic particle and penetrant testing – Equipment and protective measures when working with UV radiation

Standards USA/International

Standard	Designation
AMS 2644 (früher MIL-I-25135)	Inspection Material, Penetrant (Aviation Industry)
ASME-Code Section V, Article 6	Nondestructive Examination, Liquid Penetrant Examination (Tank Building)
ASTM E 1417	Standard Practice for Liquid Penetrant Testing
ASTM E 165	Standard Practice for Liquid Penetrant Testing for General Industry

Standards Germany / Europe / International

Standard	Designation
DIN EN ISO 12706	Penetrant testing, Terminology
DIN EN ISO 3452-1	Penetrant testing, General principles
DIN EN ISO 3452-2	Penetrant testing, Testing of penetrant materials
DIN EN ISO 3452-3	Penetrant testing, Reference test blocks
DIN EN ISO 3452-4	Penetrant testing, Equipment
DIN EN ISO 3452-5	Penetrant testing at temperatures higher than 50 °C
DIN EN ISO 3452-6	Penetrant testing at temperatures lower than 10 °C
DIN EN ISO 3059	Penetrant testing and magnetic particle testing, viewing conditions



Characterisation of testing media systems according to DIN EN ISO 3452-1

Penetrant		Intermediate cleaner		Developer	
Type	**Designation**	**Method**	**Designation**	**Form**	**Designation**
I	Fluorescent penetrant	A	Water	a	Dry developer
II	Dye penetrant	B	Lipophilic emulsifier	b	Water-based wet developer, water-soluble
III	Penetrant for two possible applications (fluorescent dye penetrant)	C	Solvent	c	Water-based wet developer, suspension
		D	Hydrophilic emulsifier	d	Solvent-based wet developer (non-aqueous with type I)
		E	Removable with water and solvent	e	Solvent-based wet developer (non-aqueous with type II and type III)
				f	Special applications (e. g. peelable developers)
				g	No developer (only with type I)

Combination e. g.: II C e or I A a, but not type II with developer form a