Crack detection

101. Crack detection through dye-penetrant inspection: General

A. General

The dye penetrant crack detection inspection is a non-destructive inspection procedure designed to detect and localize discontinuities opening onto the surface by applying capillarity processes in which highly wetting penetrating liquids are used.

B. General principles

(1) Standard procedure

Clean and dry parts.
Impregnate parts with a penetrating liquid
Allow sufficient time for the penetrating liquid to infiltrate the defects.
Remove excess dye with water or an appropriate solvent according to the type of product used.
Once the part is dry, apply a developer which usually comprises a white powder.
The developer draws off the impregnation liquid contained in the defects thus revealing their location.
Visually examine the surface and assess the results under suitable observation conditions.
Clean the surface and apply a corrosion inhibitor.

(2) Application

Applicable on all metal or non-metal materials except for porous products
Procedure applicable on moulded, wrought, welded and brazed, (etc.) products with rough or machined surface finish.
Procedure applicable to parts or assemblies of very different shapes, on the entire product or locally.
Applicable as necessary:

1. on reception of parts
2. during manufacturing cycle
3. during final inspection
4. during maintenance operations

NOTE

For magnesium alloy parts, refer to paragraph "Selecting Dye-Penetrant Products".

(3) Method selection

Choose the most economical and the most efficient method in view of the shape, volume, type and dimensions of the defects to be revealed.
The process A2 is recommended for general use. (Refer to paragraph "Selecting A Dye-Penetrant Inspection Process").

The following products are those generally recommended:

NOTE

Coloured penetrants are no longer authorized except for specific checks on aircraft and according to particular requirements.

Fluorescent penetrants which can be removed with water, used for parts or assemblies with irregular shapes (weld and brazing beads, ribs, threads, blind holes and grooves, etc.).

2. Fluorescent penetrants which can be removed with water after emulsification used for parts with standard and top grade surface finishes.
3. Products in aerosols, used preferably during missions (aircraft inspection) or on a site where fluorescent penetrants cannot be used.

(4) Surface preparation

- The surfaces to be tested must be perfectly clean in order to ensure correct penetration of the penetrating liquid and an efficient inspection.
- The dye penetrant crack detection inspection may prove to be inoperative under the following circumstances:

1. Plugging of cracks by superficial caulking of the surface to be examined subsequent to a machining operation.
2. Plugging of cracks by clogging due to the presence of solid or liquid matter (oxide, scale, oil, grease and residue, etc...).
3. Plugging of cracks by paint or anodizing or other protective treatments.

- A surface preparation is specified for each possibility.

1. Cracks plugged by superficial caulking: pickling to open the cracks.
2. Cracks plugged by clogging: degreasing.
3. Cracks plugged by paint or by protective treatment: paint removal.

NOTE

As a general rule, a check should be conducted to ensure that the mechanical treatment is not excessively reduced by the pickling operation.

- Titanium and its alloys should be pickled and degreased according to certain requirements since certain agents could be the cause of susceptibility to stress corrosion.

C. Classification of dye-penetrant inspection processes

(1) Basic processes

Fluorescent penetrants are characterized by the method used to remove excess penetrant and by their sensitivity level:

- Method A
  Fluorescent penetrants that are directly water-washable and used with dry developers (code a) or halogenated or non-halogenated liquid developers (code d).
  Method D
  Fluorescent penetrants with hydrophilic post-emulsifier with dry developers (code a) or halogenated or non-halogenated liquid developers (code d).

Classification of sensitivity levels

Level 1: Low sensitivity

Level 2: Medium sensitivity

Level 3: High sensitivity

Level 4 : Ultrahigh sensitivity.

(3) Codes for developers

Code a: Dry powder developers.

Code d: Non-aqueous developers (in suspension in a volatile organic compound).

The organic compound may be halogenated or not.

The overall inspection selected. *dye-penetrant to the developer*

Classification of developers in order of increasing sensitivity:

- Dry developer (a) applied by conventional (pneumatic) spraying.
- Dry developer (a) applied in a fog room.
- Dry developer (a) applied by electrostatic spraying.
- Halogenated, non-aqueous developer (d) applied by conventional or electrostatic spraying.
- Non-halogenated, non-aqueous developer (d) applied by conventional or electrostatic spraying.

D. Selecting a dye-penetrant inspection process

The process shall be selected according to the part to be inspected.

TYPE OF THE PART TO BE INSPECTED	DYE-PENETRANT PROCESS
STRUCTURAL ELEMENTS	
BLANKS dye-penetrant inspected before complete machining, and then subjected to a dye-penetrant inspection with higher sensitivity	
- Castings	A1a
- or forgings	A1a or A1d
castings	A2a
- Die-forgings, forgings	A2a or A2d
- Machined parts	A2a or A2d or D2a or D2d
- Welded parts	A2a or A2d
- Critical parts	A3a or A3d or D3a or D3d
TRANSMISSION COMPONENTS	
COMPONENTS subject to low or normal stress	D3a or D3d
COMPONENTS subject to high stress	D4a or D4d

NOTE

Hydrophilic post-emulsification processes (D) better withstand over-rising than pre-emulsification processes (A) and thus provide better detection of wide or shallow defects.

NOTE

For the same sensitivity, pre-emulsification processes (A) require better surface finish than hydrophilic post-emulsion processes (D).

E. Dye-penetrant inspection procedure

Refer to Work Card 20-02-09-601.

F. Selecting dye-penetrant products

CAUTION

ONLY PRODUCTS LISTED ON THE SAME LINE MAY BE USED TOGETHER.

(1)	Manufacturer			Developer (2)
A1	Ardrox Castrol Sherwin Turco Magnaflux	970 P22 Britemor 445 HM2 WP1B ZL19	- - - - -	9D6A(a): 9D6F/9D4E/9D1/9D12(d) PD3/PD4(a); LD2/LD5/LD3(d) D90G(a); D100/D100NF(d) DD2B(a); NAD(d) ZP4B(a); ZP9F(d)
A2	Ardrox Castrol Sherwin Turco Magnaflux	97OP23/97OP23E Britemor 4455 HM3A/HM406 WP100LS ZL60C	- - - - -	9D4A(a): 9D6F/9D4E/9D1/9D12(d) PD3/PD4(a); LD2/LD5/LD3(d) D90G(a); D100NF/D100(d) DD2B(a); NAD(d) ZP4B(a); ZP9F(d)
A3	Ardrox Ardrox Castrol Sherwin Turco Magnaflux	9VF2 970P25/970P25E Britemor 446 HM430/HM604 WP170LS ZL67	- - - - - -	9D1B 9D4A(a); 9D6F/9D4E/9D1/9D12(d) PD3/PD4(a); LD2/LD5/LD3(d) D90G(a) D100NF/D100(d) DD2B(a); NAD(d) ZP4B(a); ZP9F(d)
D2	Ardrox Castrol Sherwin Turco Magnaflux	985 P12 Britemor 555 RC50 P31H1 ZL2C	9PR12 H91A ER83A E41 ZR10B	9D4A(a): 9D6F/9D4E/9D1/9D12(d) PD3/PD4(a); LD2/LD5/LD3(d) D90G(a); D100NF/D100(d) DD2B(a); NAD(d) ZP4B(a); ZP9F(d)

Process	Manufacturer	Products		
		Penetrant (1)	Emulsifier	Developer (2)
D3	Ardrox Castrol Sherwin Turco Magnaflux	985 P13 Britemor 600 RC65 P41H1 ZL27A	9PR12 H91A ER83A E41 ZR10B	9D4A(a); 9D6F/9D4E/9D1/9D12(d) PD3/PD4(a); LD2/LD5/LD3(d) D90G(a); D100NF/D100(d) DD2B(a); NAD(d) ZP4B(a); ZP9F(d)
D4	Ardrox Castrol Sherwin Turco Magnaflux	985 P14 Britemor 668 RC77 P60H2 ZL37	9PR12 H91A ER83A E41 ZR10B	9D4A(a); 9D6F/9D4E/9D1/9D12(d) PD3/PD4(a); LD2/LD5/LD3(d) D90G(a); D100NF/D100(d) DD2B(a); NAD(d) ZP4B(a); ZP9F(d)

NOTE

Dye penetrants for magnesium alloys HZ5 and WE43
Ardrox 970P23E, Sherwin HM3A, Magnaflux ZL60C

(1) - 970P23E and 25E have a better rinsability than 970P23 and 25.

(1) - WP100LSBD and WP170LSBD are the biodegradable version of WP100LS and WP170LS.

(2) - (a) Dry powder, (d) Non-aqueous.

(2) - 9D4E is more volatile than 9D1.

(2) - PD4 may only be applied by electrostatic spraying.

(2) - ZP9F must not be applied by electrostatic spraying.

(2) - The manufacture of 9D6F/LD2 has been discontinued. (May be **used within expiry date, until stocks** are exhausted).