

EO 105-1-2B

ROYAL CANADIAN AIR FORCE



**DESCRIPTION AND MAINTENANCE
INSTRUCTIONS**

SURFACE DEFECT DETECTION

REVISION
NOTICE

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LIST OF RCAF REVISIONS

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SURFACE DEFECT DETECTION

INTRODUCTION

1 The early detection of flaws and deterioration of equipment, particularly of metal parts, can prevent accidents in the field and can save time and materials in the shop. Various assists to visual inspection have been developed. The sound test, the magnifying glass, and the oil and chalk test are described briefly. Of the more recent developments, namely the fluorescent penetrant method, the dye penetrant method and magnetic systems, the dye penetrant method has been selected for detailed description and general application because of the value where critical inspection is required, the portability and simplicity of equipment, and the ease of application and interpretation of results.

2 The dye penetrant method may not be applied for the detection of sub-surface flaws or imperfections not open to the surface. The method is used to detect surface cracks, porosity and through leaks. Examples include shrinkage cracks and shrinkage porosity, cold shuts, fatigue cracks, grinding and heat treatment cracks, seams, forging laps and bursts; lack of bond between joined metals, and through leaks in thin-walled casting, welds or tanks. The chemicals used are not injurious to metal or plastic.

GENERAL METHODS

3 Brief reference is made to various crack detection methods although the dye penetrant method is regarded as the most suitable for general RCAF application.

SOUND TEST

4 Metal parts which when struck produce a dull sound of short duration are to be suspected of being unsound or cracked and should be further examined.

MAGNIFYING GLASS

5 A magnifying glass may be used as a direct aid where careful visual inspection is required. The inspection of metal surfaces by this method can be facilitated by cleaning the surface with very fine emery crocus cloth.

THE OIL-CHALK TEST

6 Soak the part in solvent, petroleum, cleaner, Spec. 3-GP-8 for one to two hours. The absorption of fluid by capillary action is slow in minute cracks or in cracks in hard metal parts (e.g. polished steel castings) therefore the indication of minute surface defects is improved by long soaking. Absorption is improved if a warm oil bath is used. The surface of the part is wiped free of fluid and dusted lightly with a clinging powder, fullers earth, soapstone or chalk, french, dusting compound Spec. MAT-2-1 RCAF Ref. 33C/11. The powder acts like a blotter, drawing the cleaner fluid out of the surface defects and producing a visible stain. The staining may be increased by tapping the part with a soft-faced hammer. On crank cases or other parts exposed to oil, the surface may be washed, wiped and tapped. The oil exuded from cracks by the jarring may be detected by detail examination with a magnifying glass. This method and the penetrant methods are based on the principle of capillarity.

DYE PENETRANT TEST

7 This test involves cleaning the surface, applying a dye penetrant fluid, rinsing away excess penetrant, dusting with powder and observing the part visually. The chemicals required are listed in Figure 1.

FLUORESCENT PENETRANT TEST

8 The test procedure is similar to that given in paragraph 7, except that a fluorescent penetrant fluid replaces the dye penetrant fluid and consequently observation of the part must

be made in a darkened booth under ultra-violet or "black" light. This method is not used generally in the RCAF because an experienced observer and special equipment are required.

NOTE

Parts with

DELETED the flu-
- subsequently fail
- torily by the dye penetrant

MAGNETIC TEST

9 Methods developed around the magnetic effect produced by imperfections in metal parts all require trained and experienced operators and special equipment. These methods are unsuited for field use. The important advantage of this test method is its ability to detect the sub-surface defects.

X-RAY TEST

10 The comments of paragraph 9 apply also to this test method.

CLEANING

11 Paint and other protective coatings must be **VERY THOROUGHLY REMOVED** using paint remover Spec. 1-GP-78.

12 Grime, grease and oil are first removed by swabbing or dipping using solvent, petroleum, cleaner Spec. 3-GP-8 and wire brushing if necessary. Final cleaning and degreasing is effected by swabbing, dipping or spraying with solvent, trichlorethylene Spec. Mil-T-7003 or with the cleaner RCAF Ref. 33C/750. Allow time for the cleaner to evaporate. The surface must be dry before proceeding, see Figures 3 and 4.

NOTE

Proper cleaning is essential for true interpretation of results. Foreign particles, if left on the surface of the part, will

absorb penetrant and produce misleading stains; grease and oil prevent entry of penetrant into surface defects.

PENETRANT

13 Apply dye penetrant solution RCAF Ref. 33C/751 by swab, brush or spray. Allow the penetrant to stand in contact with the surface for three to fifteen minutes, see note and Figure 2. If the penetrant is allowed to dry, rewet the surface with penetrant and allow to stand a minute before removing, see Figure 3.

CAUTION

The penetrant is flammable, flash point 60°C (140°F).

NOTE

Penetration of the most minute surface defects by the dye penetrant is complete in fifteen minutes under normal conditions. Components made from hard metal (e. g. cast steel) require thirty minutes to one hour exposure to penetrant to allow sufficient penetrant to enter the defect. Hot air from a Nelson heater or other source may be used to warm the area to be tested on aircraft or other equipment before application of the dye penetrant solution. The efficient operation temperature range of the dye penetrant method is 20°C (70°F) to 65°C (150°F). Between 15°C (60°F) and 20°C (70°F), allow double the dwell time for satisfactory results.

REMOVAL OF EXCESS DYE PENETRANT

14 Excess penetrant may be wiped from smooth or polished surfaces. For rough surfaces, swab, brush or spray all areas covered by the penetrant with the cleaner solution and wipe clean. Repeat if necessary. Excess quantities of penetrant should be removed as thoroughly as possible but traces will not affect results, see Figure 4.

DYE PENETRANT METHOD

Materials	Specification or Trade Name	RCAF CAP 10 Ref.
Paint remover	1-GP-78	33A/456
Solvent, petroleum, cleaner	3-GP-8	33C/182
Solvent, trichlorethylene	Mil-T-7003	33C/163
Inspection penetrant		
Cleaner solution		33C/750
Dye penetrant solution		33C/751
Developer solution		33C/752
Detergent, general purpose, powder	2-GP-103	33CM/16
Chemical, acid, nitric		33C/2
Chemical, acid, phosphoric	O-P-313	33C/3
Chemical, soda ash	15-GP-5a	33C/687
Brushes		
Rags		

Figure 1 Materials

NOTE

The dye penetrant is readily removed from tool marks and burrs by the cleaner solution and thus false indications of cracks occur very seldom. Over-cleaning with cleaner solution will reduce the final stain because some penetrant will be cleaned out of the defects.

DEVELOPMENT

15 Mix contents of the developer tin, RCAF Ref. 33C/752 by vigorous and thorough shaking.

Using the pressurized spray container, spray a thin layer of developer on the areas to be inspected. A good layer is applied by spraying six to eight-inch sections from a distance of not less than eight inches. Allow developer to dry. When dry, the coating should appear translucent, see Figure 7.

CAUTION

The developer fluid is flammable, flash point 20°C (70°F).

INSPECTION

16 An immediate stain is produced if large cracks are present. A few minutes are required for small cracks to develop the best indication. Deep or extensive defects produce stains which continue to grow in size. A line or dotted line indicates a crack, lap, forging burst, or cold shut. Dots or areas of colour indicate porosity, shrinkage or lack of bond. For examples, see Figures 8 to 10. In the event that a fine line or dotted line is not thought to indicate a crack, the developer may be wiped off with a clean rag and a second coat applied. Sufficient dye penetrant will be present to provide a stain if a crack exists.

REMOVAL OF DEVELOPER

17 A soft bristle brush can be used to remove the chalk coating or developer. Detergent, general purpose, powder Spec. 2-GP-103 may be used to effect removal of the developer residue. Removal by chemical action may also be employed. a 5% solution of chemical, acid, nitric RCAF Ref. 33C/2 may be used to dissolve the developer residue from surfaces of aluminum, stainless steel and their alloys. A 5% solution of chemical, acid, phosphoric RCAF Ref. 33C/3 may be used to dissolve the developer residue from iron and steel. A final wash with a 5% solution of chemical, soda ash RCAF Ref. 33C/687 effects satisfactory corrosion inhibition on iron and steel.

CORROSION INHIBITION TREATMENT

18 The chemicals used in the dye penetrant method are harmless to metal or plastic. However, the action of the chemicals cleans and removes all organic matter and substances from the surface. Appropriate anti-corrosion or rust inhibition treatment or lubrication is required after the inspection is completed.

METHOD FOR LEAKS

19 Any thin-walled (up to 1/4") casting, weld or tank may be inspected for leaks by the dye penetrant method without use of jigs, plugs or pressure. Apply the penetrant to one side of the part by swab or spray. Allow sufficient time (fifteen minutes) for the penetrant to draw through the leak. Spray the developer suspen-

sion on the opposite side of the part and inspect for colour dots or lines.

NOTE

This method is ineffective if applied after a water test. The water will plug all fine passages and prevent capillarity of the penetrant. An air pressure test using air with high moisture content will also reduce the efficiency of the dye penetrant test for the same reason.

**MATERIALS TESTED
TYPES OF DEFECTS**

20 Figure 2 suggests examples of materials tested by the dye penetrant method, the types of defects expected, and the suggested penetration times.

Material	Types of Defects	Penetrating Time
All material	Heat treat cracks	3 minutes
	Grinding cracks	10 minutes
	Fatigue cracks	10 minutes
Plastics	Cracks	1 - 5 minutes
Ceramics	Cracks	1 - 5 minutes
	Porosity	1 - 5 minutes
Cutting Tools: Carbide tipped or steel Cutting tools	Poor braze	3 - 10 minutes
	Cracks in tip	3 - 10 minutes
	Cracks in steel	3 - 10 minutes
Metal - Permanent mould castings	Shrinkage porosity	3 - 10 minutes
Die castings	Surface porosity	3 - 10 minutes
	Cold shuts	10 - 20 minutes
Forgings	Cracks	20 minutes
	Laps	20 minutes
Metal rollings	Seams	10 - 20 minutes
Welds	Cracks	10 - 20 minutes
	Pores	10 - 20 minutes

Figure 2 Materials Tested - Types of Defects

ILLUSTRATIONS

21 A defective weld is used as an illustration of the various steps of the dye penetrant method.

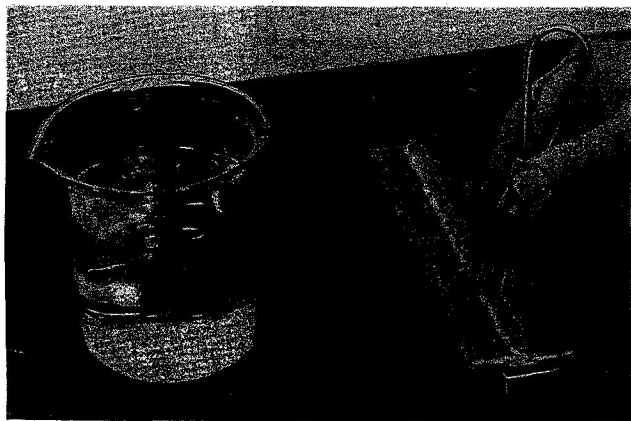


Figure 3 Precleaning Solvent, Petroleum, Cleaner and Wire Brush



Figure 5 Dye Penetrant Solution

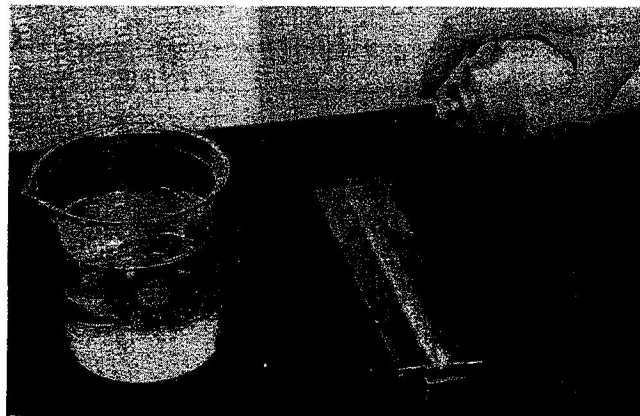


Figure 4 Cleaning Dye Penetrant Kit Cleaner Solution



Figure 6 Removal of Excess Penetrant Dye Penetrant Kit Cleaner Solution

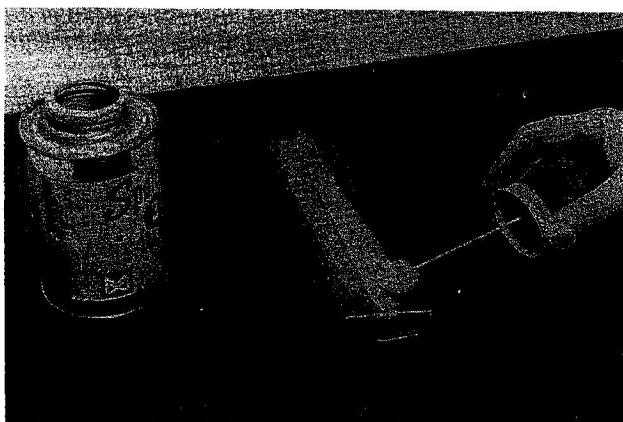


Figure 7 Developing - Dye Penetrant Developer Solution

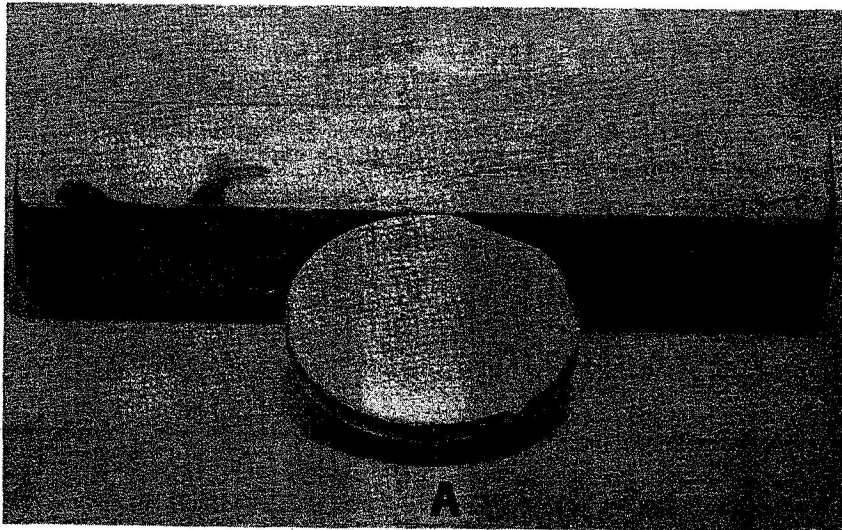


Figure 8 Spotcheck Penetrant 4 Minutes, Development 10 Minutes

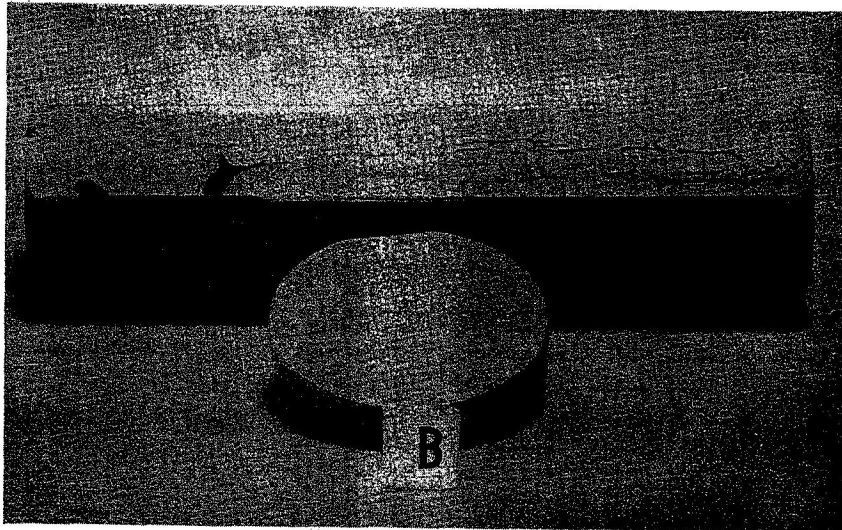


Figure 9 Spotcheck Penetrant 15 Minutes, Development 2 Minutes

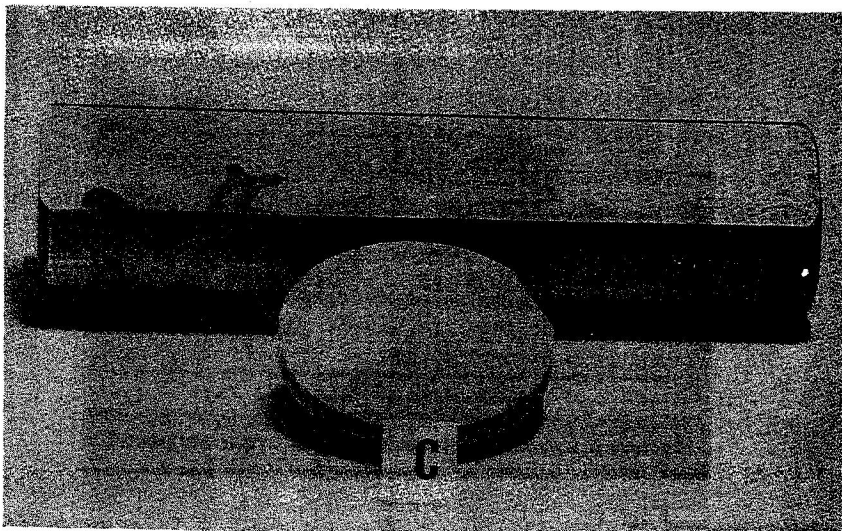


Figure 10 Ardrox Penetrant 4 Minutes, Development 10 Minutes