

## 〈解 說〉

## 침투探傷試驗의 考察

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## Consideration of Penetrant Inspection

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Penetrant testing is one of the oldest nondestructive test methods. In addition to being widely used, it is also widely misunderstood and misused.

Penetrant materials have been covered by the specification Mil-1-25135 since 1955. However, that specification needs to be updated to take into consideration the high sensitivity water washable penetrants that have been available since the mid-1960s. Also needed is inclusion of the hydrophilic emulsifiers, another level of penetrant sensitivity beyond Group IV, and a recognition of the variation in sensitivities of wet, dry, and nonaqueous wet developers. Ecological needs and material compatibility requirements have also added new materials, new procedures, and new equipment.

The basic penetrant method has not changed for many years. The recent proliferation of new materials and procedures has mostly served to widen the sensitivity range and provide better quality control of the method. There are sufficient materials from which to select and develop techniques to meet essentially any sensitivity, compatibility, or ecology requirements.

Very early in the 1950s, the need for a penetrant materials specification became apparent for military procurement. Mil-1-25135 was prepared in 1955 and the first Qualified Products List, QPL-25135, was issued in 1957.

Mil-1-25135 lists penetrants in family groups, as follows: :

- Group I – Solvent Removed Visible Dye Penetrant
- Group II – Post-Emulsified Visible Dye Penetrant
- Group III – Water-Washable Visible Dye Penetrant
- Group IV – Water-Washable Fluorescent Dye Penetrant (Low Sensitivity)
- Group V – Post-Emulsified Fluorescent Dye (Penetrant (Medium Sensitivity))
- Group VI – Post-Emulsified Fluorescent Dye Penetrant (High Sensitivity)
- Group VII – Solvent-Removed Fluorescent Penetrant Kit (consisting of Group VI penetrant, solvent, and a nonaqueous wet developer)

The sensitivity of Groups I, II, and III is approximately the same as for Group IV. These sensitivity level comparisons are valid only when the same types of developer are used. Different types of developers produce different sensitivity levels of the penetrants.

The military penetrant process specification is Mil-1-6866. This specification is method-oriented and presents the state-of-the-art for penetrant methods applications. This document presents the minimum acceptable procedures for processing with penetrant materials qualified to meet Mil-1-25135. Most penetrant materials listed on the QPL exceed the minimum requirements of Mil-1-25135, Mil-1-6866 presents six different penetrant test methods, as follows:

**Type I – Fluorescent**

Method A – Water-Washable (Group IV)

Method B – Post-Emulsified  
(Groups V and VI)

Method C – Solvent-Removed  
(Group VII)

**Type II – Visible Dye**

Method A – Water-Washable (Group III)

Method B – Post-Emulsified (Group II)

Method C – Solvent-Removed (Group I)

**Mechanisms of Penetration**

Capillary Action (Good)

Surface Tension (Low)

Contact Angle (Low)

Visibility

Type of Dye (Concentration)

Fading Characteristics

Emulsification: Time (Smooth & Rough  
Surface)

Back Ground : Variable

Flawentrapment Efficiency: Sensitivity Test

Comparison Test

Cracked Al Block

Cracked Chrome – Plated Panel.

**Penetrant Dye**

Visible Dye

The Best Sensitivity : Solvent Developer  
or Plastic Film Developer

Visible Dye : Group IV Level

**Fluorescent Dye**

Ultraviolet Light : 3650 A°

Penetrant Dye Absord Energy:  
3500- 4000 A°

Re-emit : 4750-5750 A°

**Physical Properties of Penetrant**

Viscosity : Less than 5 Centistockes

Wettingability : Contact Angle, Surface  
Tension

Specific Gravity : Less than 1

Volatility : Low

Flammability : Min 125° F

Chemical Activity : Chloride, Chlorine or  
Surphur (Austenitic Steel, TITanium, and  
High Nickel Steel)

**Washability Test (Group IV)**

Sand Blast Stainless Pannel

45° Angle, 12” Distance

30 P.S.I.

**Emulsifiers and Removers**

**Lipophilic Emulsifiers**

Oil Base Penetrant

3 Basic Properties

Activity : Emulsifier Interacts with  
the Penetrant

Visosity : 10-100 Centistockes

Water Tolerance : 15-20% Water

Flash Point : 124° F Min.

Emulsifier Tolerance : 20% Penetrant

**Hydrophilic Emulsifiers:**

Hydrophilic Means Water Loving or  
 Soluable 5 -20 Min Emulsifier Time  
 Less Dilution : Greater Tank Life  
 Low Concentration (5%): Best Sensitivity  
 (5%-33% Range)

**Mechanisms of Developer****4 Basic Function**

Drawing out a Sufficient Amount of  
 Penetrant  
 Expanding the Width  
 Increasing the Brightness  
 Increasing the Film Thickness

**5 Basic Type of Developer**

Dry Powder  
 Water Suspended  
 Water Soluable  
 Solvent Suspended  
 Plastic Film

Sensitivity Test: Cracked Chrome Plated Panel

**The Method of Penetrant Processing****Precleaning**

Detergent Cleaning  
 Vapor Degreasing  
 Steam Cleaning  
 Solvent Cleaning  
 Acid or Alkaline Cleaning  
 Abrasive Cleaning  
 Paint, Vanish and Carbon Removal  
 Ultrasonic Cleaning  
 Etching

**Application of Penetrant to Parts**

Dipping  
 Spraying  
 Flow on  
 Brushing

**Removal of Surface Penetrant****Lipophilic Emulsifier**

Smooth Surface : 30-45 Second  
 Group V : 3 Min.  
 Group VI : 5 Min.

**Hydrophilic Emulsifier**

Dwell Time : 5-20 Min.

**Procedure****Pre-Rinse**

30-60 Sec. with Water Spray

20 P.S.I.

Temp 70-80°F

**Emulsifier Dip**

Agitated by Compressed Air

Submerged 2 or 3 Min.

Dwell Time : As Necessary

**Final Rinse**

Final Rinse with Water (60-80°F)

60-120 Sec.

**Application of Developer**

No Developer

Water Suspended Developer

Dry Developer

Solvent Suspended Developer

Water Soluable Developer

Plastic Film Developer

Drying

225°F

Not to Exceed 250°F

**Inspection**

Visible Penetration Station: 100 Foot

Candle

Fluorescent Penetration Station

1500 $\mu\omega/cm^2$  at the Inspection

Surface

3000 $\mu\omega/cm^2$  for no Developer or

Critical Insp.

**Post Cleaning**

Post Cleaning is not Necessary if Dry  
Developer has been Used.

**Quality Control of Materials**

**Functional Test**

Cracked Aluminum Block  
Cracked Chromium Plated Panel

**Wetability Test**

Drop Test

**Capillary Test**

Viscosity Test

Viscometer

Fluorescent Brightness Test

Water Tolerance of Waterwashable Penetrant

Water Tolerance of Lipophilic Emulsifier

Contamination of Emulsifier by Penetrant

Hydrophilic Emulsifier Concentration in Water

Control of the Quality of the Developer.