The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL

A Product of the
Cooperative Engineering Program

SAE J426 DEC88

Liquid Penetrant Test Methods

SAE Information Report
Reaffirmed December 1988

SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
400 COMMONWEALTH DRIVE, WARRENDALE, PA 15096

MATERIALS REPORT

SAE J426

Issued June 1960
Reaffirmed December 1988

Reaffirming J426 JUN83

LIQUID PENETRANT TEST METHODS

1. PURPOSE:

The purpose of this report is to supply the user with sufficient information so that he may decide whether liquid penetrant test methods apply to his particular inspection problem. Detailed technical information can be obtained by referring to the Bibliography at the end of this report.

2. GENERAL:

Liquid penetrant testing is a sensitive, nondestructive inspection method suitable for the detection of very small discontinuities that are open to the surface. It is generally used on materials such as metals, plastics, and ceramics. However, the magnetic particle method is generally preferred for ferromagnetic materials. Specific applications include detection of cold shuts, seams, shrinkage, porosity, cracks, and other imperfections which are open to the surface of nonporous objects.

3. PRINCIPLE:

The liquid penetrant test method is based upon capillary action, using low surface tension liquids. The liquid penetrant is applied to the surface to be inspected by dipping, spraying, or brushing. The excess penetrant is removed and a developer is applied. The bleeding out of penetrant from the discontinuity into the developer yields indications which can be observed and evaluted. This is done under ultraviolet or white light, depending upon the type of liquid penetrant used--fluorescent or nonfluorescent (visible).

4. PROCEDURE:

1. Clean parts by washing, degreasing, or etching. (Paint or other surface coatings must first be removed.)

2. Apply penetrant to the surface to be inspected.

3. Allow adequate time for penetration.

4. Remove excess penetrant from the surface.

5. Dry the surface to be inspected. (Perform after the next step if a wet developer is used.)

NOTE: Excessive part temperatures can degrade penetrants.

6. Apply a developer when applicable. The developer is a material which acts like a blotter and draws penetrant from the defect. Dry or wet (aqueous or nonaqueous) developers are used.

7. Locate imperfections by observing penetrant bleed-out from the discontinuity.

8. Post clean parts. Remove residual penetrant and developer.

5. CHARACTERISTICS:

There are a number of different classifications of penetrant test materials. These are discussed in the following paragraphs:

1. Penetrants are classified into two types. One type of penetrant employs fluorescent dyes to make surface imperfections visible under ultraviolet light. The other type of penetrant employs red nonfluorescent dyes which are visible under white light.

2. The penetrants are further classified according to the method of excess penetrant removal:

6. METHOD A:

The penetrants contain an emulsifier which makes them water washable.

7. METHOD B:

The penetrants require that an emulsifier or remover (hydrophilic) be applied over the penetrants to make them water washable. Hence, they are called post-emulsifiable penetrants or remover type penetrants.

8. METHOD C:

The penetrants are solvent removable.

Generally, there are several recognized sensitivity levels of penetrant performance relating primarily to the width of discontinuity that must be detected. Selection of the excess penetrant removal method (that is, A, B, or C) and sensitivity levels will be made based upon the following factors: surface roughness, surface treatment, size of discontinuity to be disclosed, environment, production required, equipment available, type of material to be inspected, subsequent use of the part, disposal restrictions, cost, and others. Where minimal sensitivity with respect to size of discontinuities is needed, the color contrast or visible dye penetrants are usually employed and any of the three methods of penetrant removal above can be used.

Fluorescent penetrants make discontinuities more discernible. Fluorescent penetrants may be selected for use with method A, B, or C. Three principal factors affect performance: the amount and brilliance of fluorescent dye that is contained within the penetrant material and the ability of the penetrant to be retained in the surface discontinuities after surface excess is removed.

Generally, the least repeatable method is method C, solvent removable: Because the process is difficult to control accurately, results may vary widely. Either the self-emulsified, (water-washable), or the post-emulsified method will yield equivalent results if proper selection of materials is made. For ultra-high performance, a very low activity emulsifier mixture or hydrophilic remover with water is used to clean off the surface excess.

9. DEVELOPERS:

One of three types of developers is used to draw the penetrant from the discontinuities. The first, called dry developer, consists of a dry, light-colored, powdery material. Dry developer is applied to the surface of the parts after removal of the excess penetrant and drying of the part. Dry developer is applied by immersing the parts in a tank containing powder, by brushing it on with a paintbrush (usually not a desirable technique), or by blowing the powder onto the surface of the part.

The second type is aqueous wet developer and consists of powdered material suspended in water. The use of the wet developers permits rapid coverage of a large number of parts or of parts that have complicated shapes. After application of the wet developer, usually by dipping, the part is dried and then inspected for penetrant indications.

The third developer is called nonaqueous wet developer. The powdered developer is suspended in a suitable solvent and sprayed onto the surface of the dry part. The solvent evaporates quickly, leaving a fine coating of developer on the surface of the part. The nonaqueous wet developer produces very high sensitivity when inspecting parts with small, tight defects.

9. DEVELOPERS: (Continued)

Selection of the type of development method or material used for an application is important to the achievement of reliable inspections. The three types of developers vary widely in the degree of enhancement of indications. Nonaqueous wet developer, aqueous wet developer, or dry powder may be preferred depending upon the application. Surface finish may affect the degree of enhancement of developers. An aqueous developer, either soluble or particulate, should not generally be used with water-washable penetrants.

10. BIBLIOGRAPHY:

1. AMS 2645H, Fluorescent Penetrant Inspection, January 1982, SAE.
2. AMS 2646C, Contrast Dye Penetrant Inspection. April 1982, SAE.
3. AMS 3155C, Oil, Fluorescent Penetrant Solvent Soluble, July 1983, SAE.
4. AMS 3156C, Oil, Fluorescent Penetrant, Water Washable, October 1983, SAE.
5. AMS 3158A, Solution, Fluorescent Penetrant Water Base, July 1979, SAE.
6. C. E. Betz, "Principle of Penetrants," Magnaflux Corp., 1963.
7. ASTM E 165, Method for Liquid Penetant Inspection.
8. ASTM E 270, Definitions of Terms Relating to Liquid Penetrant Inspection.
9. MIL-1-6866B (ASG), Inspection, Penetrant Method of.
10. MIL-1-25135C (ASG), Materials, Penetrant.
11. Nondestructive Testing Handbook, R. C. McMaster, ed., Columbus, OH 43228. American Society for Nondestructive Testing, Volume 2, "Liquid Penetrant Tests" Second Edition, 1982.
12. Programmed Instruction Handbook PI-4-2. Convair Div., General Dynamics Corp., 1967.
13. Recommended Practice SNT-TC-1A, Supplement D-Liquid Penetrant, Qualification and Certification of Personnel, American Society for Nondestructive Testing, Columbus, OH 43221.
14. Metals Handbook, Volume 11, 1976, pp. 20-44, American Society for Metals, Metals Park, OH 44073.

RATIONALE:

Not applicable.

RELATIONSHIP OF SAE STANDARD TO ISO STANDARD:

Not applicable.

REFERENCE SECTION:

AMS 2645H, Fluorescent Penetrant Inspection, January 1982, SAE.

AMS 2646C, Contrast Dye Penetrant Inspection. April 1982, SAE.

AMS 3155C, Oil, Fluorescent Penetrant Solvent Soluble, July 1983, SAE.

AMS 3156C, Oil, Fluorescent Penetrant, Water Washable, October 1983, SAE.

AMS 3158A, Solution, Fluorescent Penetrant Water Base, July 1979, SAE.

C. E. Betz, "Principle of Penetrants." Magnaflux Corp., 1963.

ASTM E 165, Method for Liquid Penetant Inspection.

ASTM E 270, Definitions of Terms Relating to Liquid Penetrant Inspection.

MIL-1-6866B (ASG), Inspection, Penetrant Method of.

MIL-1-25135C (ASG), Materials, Penetrant.

Nondestructive Testing Handbook, R. C. McMaster, ed., Columbus, OH 43228. American Society for Nondestructive Testing, Volume 2, "Liquid Penetrant Tests" Second Edition, 1982.

Programmed Instruction Handbook PI-4-2. Convair Div., General Dynamics Corp., 1967.

Recommended Practice SNT-TC-1A, Supplement D-Liquid Penetrant, Qualification and Certification of Personnel, American Society for Nondestructive Testing, Columbus, OH 43221.

Metals Handbook, Volume 11, 1976, pp. 20-44, American Society for Metals, Metals Park, OH 44073.

APPLICATION:

The purpose of this report is to supply the user with sufficient information so that he may decide whether liquid penetrant test methods apply to his particular inspection problem. Detailed technical information can be obtained by referring to the Bibliography at the end of this report.

COMMITTEE COMPOSITION:

DEVELOPED BY SAE DIVISION 25 - NONDESTRUCTIVE TEST METHODS:

G. L. Anderson, Amer. Gas & Chem. Co. Ltd., Northvale, NJ
G. B. Chapman II, Chrysler Corp., Detroit, MI
D. D. Dodge, Dearborn, MI
W. C. Hitt, Placerville, CA
T. W. Judd, Republic Steel Corporation, Independence, OH
P. C. McEleney, Department of the Army, Watertown, MA
J. A. Patsey, USX Corp., Pittsburgh, PA
J. K. Schmitt, Chrysler Corp., Highland Park, MI
R. W. Thams, X-Ray Industries, Inc., Troy, MI
R. J. Torre, Mt. Clemens, MI

SPONSORED BY THE SAE IRON AND STEEL TECHNICAL COMMITTEE:

G. G. Witt, Ford Motor Company, Dearborn, MI - Chairman
F. J. Arabia, General Motors Corp., Warren, MI
R. J. Belz, Bloomfield Hills, MI
R. D. Bennett, White Farm Equip. Co., Charles City, IA
F. P. Bens, Kolene Corp., Detroit, MI
E. T. Bittner, Brookfield, WI
H. N. Bogart, Traverse City, MI
F. Borik, Climax Molybdenum Company, Ann Arbor, MI
R. W. Buenneke, Caterpillar, Inc., East Peoria, IL
E. F. Chojnowski, Heat Transfer Systems Co., Jackson, MI
A. G. Cook, Oakmont, PA
W. J. Cormack, Caterpillar, Inc., E. Peoria, IL
D. D. Day, Meehanite Worldwide, Fairlawn, OH
S. Denner, National Steel Corp., Livonia, MI
S. Dinda, Chrysler Corporation, Detroit, MI
D. V. Doane, Ann Arbor, MI
J. M. Dobos, Ford Motor Co., Dearborn, MI
J. R. Easterday, Kolene Corp., Detroit, MI
I. Ekis, Mercury Marine, Oshkosh, WI
R. Fabian, Lindberg Heat Treating Co., Berlin, CT
M. L. Frey, Leesburg, FL
C. N. Grant, General Motors Corp., Flint, MI
J. S. Hanson, Lathrop Village, MI
K. W. Jerwann, General Electric Co., Fitchburg, MA
E. H. Judd, Associated Spring Co., Livonia, MI
R. Krupitzer, Chrysler Motors, Detroit, MI
J. M. Larson, Eaton Corp., Marshall, MI
A. S. MacDonald, Hagerstown, MD
D. E. McVicker, Allentown, PA
W. J. Ptashnik, GMC, Troy, MI
E. R. D. Ritchie, John Deere Component Works, Waterloo, IA
E. F. Ryntz, Jr., General Motors Corp., Warren, MI
S. R. Scales, Houston, TX
E. J. Schneider, USX Corp., Pittsburgh, PA