



Designation: E 592 – 99

Standard Guide to Obtainable ASTM Equivalent Penetrameter Sensitivity for Radiography of Steel Plates ¼ to 2 in. (6 to 51 mm) Thick with X Rays and 1 to 6 in. (25 to 152 mm) Thick with Cobalt-60¹

This standard is issued under the fixed designation E 592; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This guide to obtainable equivalent penetrameter sensitivity covers the minimum penetrameter thicknesses for which the image of the 1T and 2T holes is visible for a few practical radiographic conditions. The values represent near optimum sensitivity for flat steel plates. Radiographic conditions that give higher values of scatter buildup from the specimen or backscattered radiation at the image plane will give poorer sensitivity.

1.2 Eight radiographs that illustrate sensitivities obtainable with practical radiographic systems are included as adjuncts to this guide and may be obtained from ASTM.

1.3 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

E 746 Test Method for Determining Relative Image Quality Response of Industrial Radiographic Film²

E 999 Guide for Controlling the Quality of Industrial Radiographic Film Processing²

E 1025 Practice for Design, Manufacture, and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology²

E 1316 Terminology for Nondestructive Examinations²

2.2 ANSI Standard:

ANSI PH2.8 Sensitometry of Industrial X-ray Films for Energies up to 3 Million Electron Volts³

2.3 Military Standard:

MIL-STD-271 Nondestructive Testing Requirements for Metals⁴

2.4 ASTM Adjuncts:

Guide for Equivalent Penetrameter Sensitivity Between X Rays and Cobalt-60⁵

3. Terminology

3.1 *Definitions:* —For definitions of terms used in this standard, refer to Terminology E 1316, Section D.

4. Significance and Use

4.1 A key consideration with any radiographic system is its capability to resolve detail (that is, sensitivity). The degree of obtainable sensitivity with a given system is dependent upon several radiographic parameters such as source energy level, film type, type and thickness of intensifying screens, exposure (density), etc. This guide permits the user to estimate the degree of sensitivity that may be obtained with X rays and cobalt-60 gamma rays when using a prescribed set of radiographic parameters. This guide may also be used in conjunction with Test Method E 746 to provide a basis for developing data for evaluation of a user's specific system. This data may assist a user in determining appropriate parameters for obtaining desired degrees of radiographic system sensitivity. An alternate to this approach is the use of those adjunct radiographic illustrations detailed in Section 6.

5. Procedure

5.1 *Sensitivity for ¼ to 2-in. (6 to 51-mm) Thick Steel Using X Rays:*

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² *Annual Book of ASTM Standards*, Vol 03.03.

³ Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

⁴ Available from Standardization Documents Order Desk, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111-5094, Attn: NPODS.

⁵ Available from ASTM Headquarters. Order RRE0592.

5.1.1 The values of sensitivity were determined from a statistical study of visibility of images of penetrameter holes. Near 100 % certainty of seeing the image of a hole on any radiograph was taken as the criterion for determining sensitivity. Most radiographs will show slightly better sensitivity than indicated in Figs. 1-3 because of the statistical nature of recording information from a beam of X rays but occasionally, one will not show quite as good sensitivity.

5.1.2 Fig. 1 illustrates obtainable equivalent penetrameter sensitivity (see Appendix X1 of Practice E 1025) for four X-ray films. The films are identified by reciprocal roentgen speed when exposed in accordance with ANSI PH2.8 in a 200-kV range, and processed in accordance with the manufacturer's recommendations (see Guide E 999).

Film No.	Speed
1	17
2	4.0
3	1.2
4	0.35

5.1.3 The radiographic exposure conditions were: 36-in. (914-mm) focus-film distance, 5-mil (0.13-mm) front and 10-mil (0.25-mm) back lead screens, 20 mA·min exposure, and kilovoltage adjusted to give a density of near 2.0.

5.1.4 Most high-quality industrial X-ray films intended for direct or lead screen exposure, that are exposed and developed accordingly to give these speed values, will provide similar illustrations of sensitivity. Interpolation will give illustrations of sensitivity for speeds obtained with other film systems.

5.1.5 In Fig. 2 the data are presented to show the thinnest penetrameter for which the image of the 2T hole will be visible. The intersection of the line for a particular steel thickness and the line for a given film projected onto the abscissa gives the best obtainable equivalent penetrameter sensitivity. The intersection projected to the left ordinate gives the minimum penetrameter marking (thickness in mils) in accordance with

Practice E 1025 for which the image of the 2T hole will be visible. The right ordinate gives the minimum marking in accordance with MIL-STD-271 for which the image of the 2T hole will be visible.

5.1.6 Fig. 3 gives the ASTM and military markings for which the image of the 1T hole will be visible.

5.1.7 To take an example, on Fig. 2 the intersection of the curve for 1-in. (25-mm) thick steel and for Film No. 2 shows that the penetrameter sensitivity is 1.45 %. The minimum ASTM penetrameter thickness that will show the 2T hole image is 15. The corresponding military marking is 0.75 (see dashed lines). On Fig. 3 the sensitivity is, of course, 1.45 %. The minimum ASTM penetrameter thickness that will show the 1T hole image is 22 and the military specification marking is 1.1.

5.1.8 If radiographs are exposed to a density other than 2 by changing mA·min exposure, but not kilovoltage, the equivalent penetrameter sensitivity (EPS) that will be obtained in the density range 1.3 to 4 can be calculated approximately as follows:

$$EPS_D = EPS_2 (2/D)^{1/4} \tag{1}$$

where:

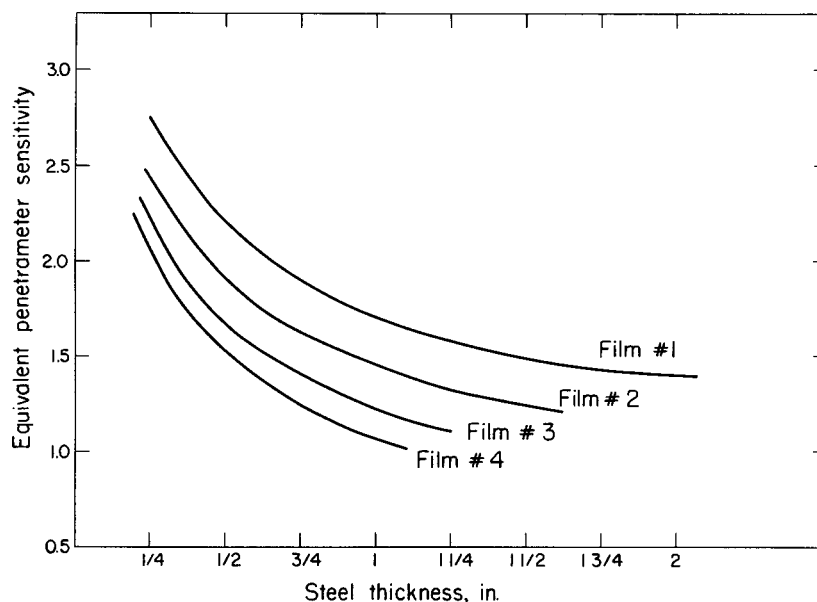
- D = density to which the radiograph is exposed,
- EPS_2 = sensitivity for $D = 2.0$, and
- EPS_D = sensitivity for D .

NOTE 1—A clear definition of equivalent penetrameter sensitivity has not been established for penetrameters less than 10 mils (0.25 mm) thick. For this work it was calculated as follows:

$$EPS, \% = 70.7 (dT)^{1/2}/t \tag{2}$$

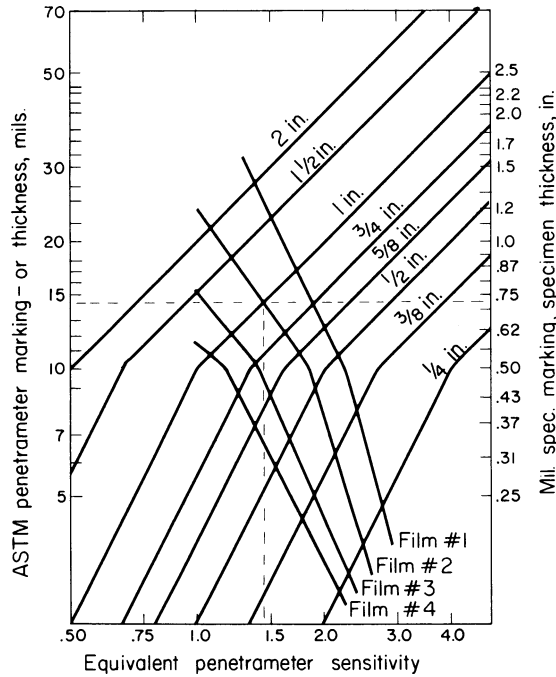
where:

- d = diameter of penetrameter hole,
- T = thickness of penetrameter, and
- t = specimen thickness.

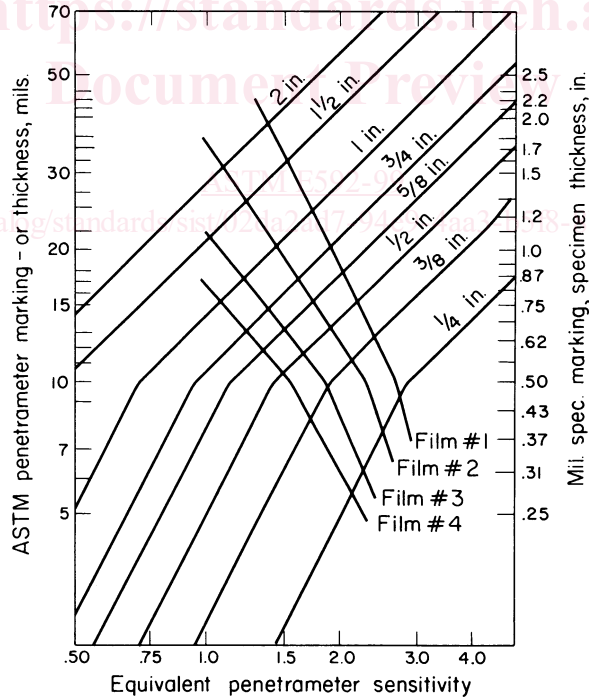


NOTE 1—See 5.1.3 for exposure conditions.

FIG. 1 Obtainable Penetrameter Sensitivity for 1/4 to 2-in. (6 to 51-mm) Thick Steel When Radiographing with X Rays.



NOTE 1—See 5.1.3 for exposure conditions.
FIG. 2 Penetrometer Sensitivity and Minimum Penetrometer Markings for Showing the 2T Hole When Radiographing 1/4 to 2-in. (6 to 51-mm) Thick Steel with X Rays.



NOTE 1—See 5.1.3 for exposure conditions.
FIG. 3 Penetrometer Sensitivity and Minimum Penetrometer Markings for Showing the 1T Hole When Radiographing 1/4 to 2-in. (6 to 51-mm) Thick Steel with X Rays.

The change in slope of the steel thickness curves on Figs. 2 and 3 is a result of the established 10-mil minimum hole diameter.

5.2 Sensitivity for 1 to 6-in. (25 to 152-mm) Thick Steel Using Cobalt-60: