



## Standard Reference Radiographs for Steel Fusion Welds<sup>1</sup>

This standard is issued under the fixed designation E 390; 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 reappraisal. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reappraisal.

*This standard has been approved for use by agencies of the Department of Defense.*

### 1. Scope

1.1 This standard provides reference radiographs for steel fusion welds that contain typical discontinuities with varying severity levels in different thicknesses of material.

1.2 There are three volumes of reference radiographs based on seven nominal weld thicknesses as follows:

Vol I—Set of 16 plates (8½ by 11 in.) covering base material up to and including ¼ in. (6.4 mm) in thickness.

Vol II—Set of 29 plates (8½ by 11 in.) covering base material over ¼ to and including 3 in. (6.4 to 76 mm) in thickness.

Vol III—Set of 32 plates (8½ by 11 in.) covering base material over 3 to including 8 in. (76 to 203 mm) in thickness.

1.3 The values stated in inch-pound units are to be regarded as the standard.

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 94 Guide for Radiographic Testing<sup>2</sup>

E 1316 Terminology for Nondestructive Examinations<sup>2</sup>

#### 2.2 ASTM Adjuncts:<sup>3</sup>

Reference Radiographs for Steel Fusion Welds:

Volume I, Thickness Up to and Including ¼ in. (6.4 mm)<sup>4</sup>

Volume II, Thickness Over ¼ to 3 in. (6.4 to 76 mm), incl<sup>5</sup>

Volume III, Thickness Over 3 to 8 in. (76 to 203 mm), incl<sup>6</sup>

### 3. Terminology

3.1 *Definitions*—For definitions of terms used in this document, see Terminology E 1316, Section D.

<sup>1</sup> These reference radiographs are under the jurisdiction of ASTM Committee E-7 on Nondestructive Testing and are the direct responsibility of Subcommittee E07.02 on Reference Radiographs.

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<sup>2</sup> *Annual Book of ASTM Standards*, Vol 03.03.

<sup>3</sup> Available from ASTM Headquarters.

<sup>4</sup> Order RRE039001.

<sup>5</sup> Order RRE039002.

<sup>6</sup> Order RRE039003.

### 4. Significance and Use

4.1 These reference radiographs may be used as a means for establishing the types and severity levels of discontinuities that are revealed by radiographic examination of steel fusion welds.

4.2 Each volume contains illustrations of representative graded and ungraded discontinuities applicable to seven thickness ranges, as shown in Table 1. Table 2 lists the discontinuity types and severities illustrated for each thickness of base material. Each of the graded discontinuity types has five severity levels, 1 through 5 in order of increasing severity. The ungraded discontinuities are included for informational purposes.

4.3 These reference radiographs may be used in contractual specifications, for which agreement has been reached between purchaser and supplier, to establish acceptance limits of the types and severity levels of discontinuities revealed by radiographic examination.

4.4 The use of this document is not intended to be restricted to the specific energy levels given in Table 3 or to the thickness limits given in Table 1. This document may be used, where there is no other applicable document, for other energy levels or thicknesses, or both, for which it is found to be applicable and for which agreement has been reached between purchaser and manufacturer.

### 5. Preparation of Reference Radiographs

5.1 The illustration in Vol I and the first two thicknesses of Vol II are radiographic while those in the thick section of Vol II (2 in.) and Vol III are photographic reproductions.

5.2 The radiographs were made to a quality level of at least 2-2T penetrameter sensitivity.

5.3 Table 3 lists the technique used in producing the original radiographs. The data are included for information and are not to be construed as the recommended technique.

5.4 The radiographic exposure was controlled so as to produce an  $H$  and  $D$  density of from 2.00 to 2.25 in a selected location on the weld bead. The reproductions used in Vol III were prepared to the same density requirements and they substantially retain the contrast and detail of the original radiographs.

### 6. Description of Discontinuities

6.1 *Porosity* occurs as voids caused by gas trapped in the

TABLE 1 Applicable Thickness Ranges

Illustration Thickness, in. (mm)	Base Material Thickness Range, in. (min) <sup>A</sup>
Vol I	
0.030 (0.8)	to and including 0.050 (3.3)
0.080 (2.0)	over 0.050 (1.3) to and including 1/8 (3.2)
3/16 (4.8)	over 1/8 (3.2) to and including 1/4 (6.4)
Vol II	
3/8 (9.5)	over 1/4 (6.4) to and including 1/2 (13)
3/4 (19)	over 1/2 (13) to and including 1 1/2 (48)
2 (51)	over 1 1/2 (48) to and including 3 (76)
Vol III	
5 (127)	over 3.0 (75) to and including 8 (203)

<sup>A</sup> In the special cases of joining two members of unequal thickness, the standard applicable to the thinner member shall be used.

TABLE 2 Types of Discontinuities Illustrated for Each Thickness of Base Material

Discontinuity Type	Base Material Thickness and Grading, in. (mm)						
	0.030 (0.8)	0.080 (2.0)	3/16 (4.8)	3/8 (9.5)	3/4 (19)	2 (51)	5 (127)
Scattered porosity							Grade 1-5
Fine scattered porosity	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	
Coarse scattered porosity	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	
Clustered porosity	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5
Linear porosity (globular indications) <sup>A</sup>	ungraded	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5
Slag inclusions		Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5
Tungsten inclusions	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	ungraded	
Incomplete penetration		ungraded	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5
Lack of fusion	ungraded		Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5	Grade 1-5
Elongated or worm hole porosity	ungraded		ungraded	ungraded	ungraded	ungraded	
Burn through	ungraded		ungraded	ungraded	ungraded	ungraded	
Icicles (teardrops)	ungraded		ungraded	ungraded	ungraded	ungraded	
Longitudinal crack		ungraded	ungraded	ungraded	ungraded	ungraded	ungraded
Transverse crack	ungraded		ungraded	ungraded	ungraded	ungraded	ungraded
Crater crack	ungraded		ungraded	ungraded	ungraded	ungraded	ungraded
Undercut	ungraded		ungraded	ungraded	ungraded	ungraded	

<sup>A</sup> The severity of linear porosity (globular indications) should be judged by their length and clustering rather than by their radiographic (*H* and *D*) density.

TABLE 3 Radiographic Technique<sup>A</sup>

Base Material Thickness, in. (mm)	kVp	mA	Timers	Source-to-Film Distance, in.	Screens in Cassettes	Film Type ASTM E 94 <sup>B</sup>
Vol I						
0.030 (0.8)	90	10	180-210	48	none	1
0.080 (2.0)	120	10	150-210	48	none	1
3/16 (4.8)	150	10	180-270	48	0.005 in. Pb front 0.010 in. Pb back	1
Vol II						
3/8 (9.5)	175	10	175-200	48	0.005 in. Pb front 0.010 in. Pb back	<sup>C</sup>
3/4 (19)	250	10	43-65	60	0.005 in. Pb front 0.010 in. Pb back	1
2 (51)	2000 or <sup>60</sup> Co <sup>D</sup>	1.5	45-53	108	0.005 in. Pb front 0.010 in. Pb back	1
Vol III						
5 (203)	2000 or <sup>60</sup> Co <sup>D</sup>	1.5	420-450	108		1

<sup>A</sup> All films were processed by automatic film processors.

<sup>B</sup> ASTM Guide E 94.

<sup>C</sup> Not defined in Guide E 94; manufacturers' description is—ultra fine grain, high contrast.

<sup>D</sup> These reference radiographs were made with <sup>60</sup>Co.

weld metal deposit. The voids may occur as spherical, elongated, or “worm hole” shapes and in patterns that are random, clustered, or linear. On a radiograph the spherical voids have the appearance of a rounded dark area while the nonspherical

voids have an elongated dark area with a smooth outline.

6.2 *Tungsten Inclusions* are tungsten particles entrapped in the weld deposit. These inclusions are particles broken off or melted from the electrodes and may be caused by faulty