

## SECTION 8—METHODS OF EXAMINING JOINTS

**NOTE** In this standard, the term inspector, as used in Sections V and VIII of the ASME Code, shall be interpreted to mean the Purchaser's inspector.

### 8.1 Radiographic Method

For the purposes of this paragraph, plates shall be considered of the same thickness when the difference in their specified or design thickness does not exceed 3 mm ( $1/8$  in.).

#### 8.1.1 Application

Radiographic examination is required for shell butt-welds (see 8.1.2.2, 8.1.2.3, and 8.1.2.4), annular-plate butt-welds (see 8.1.2.9), and flush-type connections with butt-welds (see 5.7.8.11). Radiographic examination is not required for the following: roof-plate welds, bottom-plate welds, welds joining the top angle to either the roof or shell, welds joining the shell plate to the bottom plate, welds in nozzle and manway necks made from plate, or appurtenance welds to the tank.

#### 8.1.2 Number and Location of Radiographs

**8.1.2.1** Except when omitted under the provisions of A.3.4, radiographs shall be taken as specified in 8.1.2 through 8.1.9.

**8.1.2.2** The following requirements apply to vertical joints.

- a) For butt-welded joints in which the thinner shell plate is less than or equal to 10 mm ( $3/8$  in.) thick, one spot radiograph shall be taken in the first 3 m (10 ft) of completed vertical joint of each type and thickness welded by each welder or welding operator. The spot radiographs taken in the vertical joints of the lowest course may be used to meet the requirements of Note 3 in Figure 8.1 for individual joints. Thereafter, without regard to the number of welders or welding operators, one additional spot radiograph shall be taken in each additional 30 m (100 ft) (approximately) and any remaining major fraction of vertical joint of the same type and thickness. At least 25 % of the selected spots shall be at junctions of vertical and horizontal joints, with a minimum of two such intersections per tank. In addition to the foregoing requirements, one random spot radiograph shall be taken in each vertical joint in the lowest course (see the top panel of Figure 8.1).
- b) For butt-welded joints in which the thinner shell plate is greater than 10 mm ( $3/8$  in.) but less than or equal to 25 mm (1 in.) in thickness, spot radiographs shall be taken according to Item a. In addition, all junctions of vertical and horizontal joints in plates in this thickness range shall be radiographed; each film shall clearly show not less than 75 mm (3 in.) of vertical weld and 50 mm (2 in.) of weld length on each side of the vertical intersection. In the lowest course, two spot radiographs shall be taken in each vertical joint: one of the radiographs shall be as close to the bottom as is practicable, and the other shall be taken at random (see the center panel of Figure 8.1).
- c) Vertical joints in which the shell plates are greater than 25 mm (1 in.) thick shall be fully radiographed. All junctions of vertical and horizontal joints in this thickness range shall be radiographed; each film shall clearly show not less than 75 mm (3 in.) of vertical weld and 50 mm (2 in.) of weld length on each side of the vertical intersection (see the bottom panel of Figure 8.1).
- d) The butt-weld around the periphery of an insert plate or thickened insert plate that extends less than the adjacent shell course height and that contains shell openings (i.e. nozzle, manway, flush-type cleanout, flush type shell-connection) and their reinforcing elements shall be completely radiographed.



- e) The butt-weld around the periphery of an insert plate or thickened insert plate that extends to match the adjacent shell course height shall have the vertical and the horizontal butt welds and the intersections of vertical and horizontal weld joints radiographed using the same rules that apply to the weld joints in adjacent shell plates in the same shell course.

**8.1.2.3** One spot radiograph shall be taken in the first 3 m (10 ft) of completed horizontal butt joint of the same type and thickness (based on the thickness of the thinner plate at the joint) without regard to the number of welders or welding operators. Thereafter, one radiograph shall be taken in each additional 60 m (200 ft) (approximately) and any remaining major fraction of horizontal joint of the same type and thickness. These radiographs are in addition to the radiographs of junctions of vertical joints required by Item c of 8.1.2.2 (see Figure 8.1).

**8.1.2.4** The number of spot radiographs required herein shall be applicable on a per tank basis, irrespective of the number of tanks being erected concurrently or continuously at any location.

**8.1.2.5** It is recognized that in many cases the same welder or welding operator does not weld both sides of a butt joint. If two welders or welding operators weld opposite sides of a butt joint it is permissible to examine their work with one spot radiograph. If the radiograph is rejected, the welder or the welding operator responsible for the rejectable welding shall be determined by the depth of repair, by use of additional NDE, or a combination thereof. If the determination proves inconclusive, both welders or welding operators shall be deemed at fault.

**8.1.2.6** An equal number of spot radiographs shall be taken from the work of each welder or welding operator in proportion to the length of joints welded.

- **8.1.2.7** As welding progresses, radiographs shall be taken as soon as it is practicable. The locations where spot radiographs are to be taken may be determined by the Purchaser's inspector.

**8.1.2.8** Each radiograph shall clearly show a minimum of 150 mm (6 in.) of weld length. The film shall be centered on the weld and shall be of sufficient width to permit adequate space for the location of identification marks and an image quality indicator (IQI) penetrometer

**8.1.2.9** When bottom annular plates are required by 5.5.1, or by M.4.1, the radial joints shall be radiographed as follows: (a) For double-welded butt joints, one spot radiograph shall be taken on 10 % of the radial joints; (b) For single-welded butt joints with permanent or removable back-up bar, one spot radiograph shall be taken on 50 % of the radial joints. Extra care must be exercised in the interpretation of radiographs of single-welded joints that have a permanent back-up bar. In some cases, additional exposures taken at an angle may determine whether questionable indications are acceptable. The minimum radiographic length of each radial joint shall be 150 mm (6 in.). Locations of radiographs should be at the outer edge of the joint where the shell plate and annular plate join.

### 8.1.3 Technique

**8.1.3.1** Except as modified in this section, the radiographic examination method employed shall be in accordance with Section V, Article 2, of the ASME Code.

**8.1.3.2** Personnel who perform and evaluate radiographic examinations according to this section shall be qualified and certified by the Manufacturer as meeting the requirements of certification as generally outlined in Level II or Level III of ASNT SNT-TC-1A (including applicable supplements) or ISO Std 9712. Level-I personnel may be used if they are given written acceptance/rejection procedures prepared by Level-II or Level-III personnel. These written procedures shall contain the applicable requirements of Section V, Article 2, of the ASME Code. In addition, all Level-I personnel shall be under the direct supervision of Level-II or Level-III personnel.

**8.1.3.3** The requirements of T-285 in ASME Section V, Article 2, are to be used only as a guide. Final acceptance of radiographs shall be based on the ability to see the prescribed image quality indicator (IQI) (penetrameter) and the specified hole or wire.

**8.1.3.4** The finished surface of the weld reinforcement at the location of the radiograph shall either be flush with the plate or have a reasonably uniform crown not to exceed the following values:

Plate Thickness mm (in.)	Maximum Thickness of Reinforcement mm (in.)
$\leq 13$ ( $1/2$ )	1.5 ( $1/16$ )
$> 13$ ( $1/2$ ) to 25 (1)	2.5 ( $3/32$ )
$> 25$ (1)	3 ( $1/8$ )

#### • 8.1.4 Submission of Radiographs

Before any welds are repaired, the radiographs shall be submitted to the inspector with any information requested by the inspector regarding the radiographic technique used.

#### 8.1.5 Radiographic Standards

Welds examined by radiography shall be judged as acceptable or unacceptable by the standards of Paragraph UW-51(b) in Section VIII of the ASME Code.

#### • 8.1.6 Determination of Limits of Defective Welding

When a section of weld is shown by a radiograph to be unacceptable under the provisions of 8.1.5 or the limits of the deficient welding are not defined by the radiograph, two spots adjacent to the section shall be examined by radiography; however, if the original radiograph shows at least 75 mm (3 in.) of acceptable weld between the defect and any one edge of the film, an additional radiograph need not be taken of the weld on that side of the defect. If the weld at either of the adjacent sections fails to comply with the requirements of 8.1.5, additional spots shall be examined until the limits of unacceptable welding are determined, or the erector may replace all of the welding performed by the welder or welding operator on that joint. If the welding is replaced, the inspector shall have the option of requiring that one radiograph be taken at any selected location on any other joint on which the same welder or welding operator has welded. If any of these additional spots fail to comply with the requirements of 8.1.5, the limits of unacceptable welding shall be determined as specified for the initial section.

#### 8.1.7 Repair of Defective Welds

**8.1.7.1** Defects in welds shall be repaired by chipping or melting out the defects from one side or both sides of the joint, as required, and rewelding. Only the cutting out of defective joints that is necessary to correct the defects is required.

- **8.1.7.2** All repaired welds in joints shall be checked by repeating the original examination procedure and by repeating one of the testing methods of 7.3, subject to the approval of the Purchaser.

#### 8.1.8 Record of Radiographic Examination

**8.1.8.1** The Manufacturer shall prepare a radiograph map showing the final location of all radiographs taken along with the film identification marks.

- **8.1.8.2** After the structure is completed, the films shall be the property of the Purchaser unless otherwise agreed upon by the Purchaser and the Manufacturer.

## **8.2 Magnetic Particle Examination**

**8.2.1** When magnetic particle examination is specified, the method of examination shall be in accordance with Section V, Article 7, of the ASME Code.

**8.2.2** Magnetic particle examination shall be performed in accordance with a written procedure that is certified by the Manufacturer to be in compliance with the applicable requirements of Section V of the ASME Code.

**8.2.3** The Manufacturer shall determine that each magnetic particle examiner meets the following requirements.

- a) Has vision (with correction, if necessary) to be able to read a Jaeger Type 2 standard chart at a distance of not less than 300 mm (12 in.) and is capable of distinguishing and differentiating contrast between the colors used. Examiners shall be checked annually to ensure that they meet these requirements.
- b) Is competent in the technique of the magnetic particle examination method, including performing the examination and interpreting and evaluating the results; however, where the examination method consists of more than one operation, the examiner need only be qualified for one or more of the operations.

**8.2.4** Acceptance standards and the removal and repair of defects shall be in accordance with Section VIII, Annex 6, Paragraphs 6-3, 6-4, and 6-5, of the ASME Code.

## **8.3 Ultrasonic Examination**

### **8.3.1 Ultrasonic Examination in Lieu of Radiography**

When ultrasonic examination is applied in order to fulfill the requirement of 7.3.2.1, the provisions of Annex U shall apply.

### **8.3.2 Ultrasonic Examination NOT in Lieu of Radiography**

**8.3.2.1** When the radiographic method is applied in order to fulfill the requirement of 7.3.2.1, then any ultrasonic examination specified shall be in accordance with this section.

**8.3.2.2** The method of examination shall be in accordance with Section V, Article 4, of the ASME Code.

**8.3.2.3** Ultrasonic examination shall be performed in accordance with a written procedure that is certified by the Manufacturer to be in compliance with the applicable requirements of Section V of the ASME Code.

**8.3.2.4** Examiners who perform ultrasonic examinations under this section shall be qualified and certified by the Manufacturers as meeting the requirements of certification as generally outlined in Level II or Level III of ASNT SNT-TC-1A (including applicable supplements) or ISO Std 9712. Level-I personnel may be used if they are given written acceptance/rejection criteria prepared by Level-II or Level-III personnel. In addition, all Level-I personnel shall be under the direct supervision of Level-II or Level-III personnel.

- **8.3.2.5** Acceptance standards shall be agreed upon by the Purchaser and the Manufacturer.

## **8.4 Liquid Penetrant Examination**

**8.4.1** When liquid penetrant examination is specified, the method of examination shall be in accordance with Section V, Article 6, of the ASME Code.

**8.4.2** Liquid penetrant examination shall be performed in accordance with a written procedure that is certified by the Manufacturer to be in compliance with the applicable requirements of Section V of the ASME Code.

**8.4.3** The Manufacturer shall determine and certify that each liquid penetrant examiner meets the following requirements.

- a) Has vision (with correction, if necessary) to enable him to read a Jaeger Type 2 standard chart at a distance of not less than 300 mm (12 in.) and is capable of distinguishing and differentiating contrast between the colors used. Examiners shall be checked annually to ensure that they meet these requirements.
- b) Is competent in the technique of the liquid penetrant examination method for which he is certified, including making the examination and interpreting and evaluating the results; however, where the examination method consists of more than one operation, the examiner may be certified as being qualified for one or more of the operations.

**8.4.4** Acceptance standards and the removal and repair of defects shall be in accordance with Section VIII, Annex 8, Paragraphs 8-3, 8-4, and 8-5, of the ASME Code.

## 8.5 Visual Examination

**8.5.1** The Manufacturer shall determine and certify that each visual examiner meets the following requirements.

- a) Has vision (with correction, if necessary) to be able to read a Jaeger Type 2 standard chart at a distance of not less than 300 mm (12 in.) and is capable of passing a color contrast test. Examiners shall be checked annually to ensure that they meet this requirement; and
- b) Is competent in the technique of the visual examination, including performing the examination and interpreting and evaluating the results; however, where the examination method consists of more than one operation, the examiner performing only a portion of the test need only be qualified for the portion that the examiner performs.

**8.5.2** A weld shall be acceptable by visual examination if the inspection shows the following.

- a) There are no crater cracks, other surface cracks or arc strikes in or adjacent to the welded joints.
- b) Maximum permissible undercut is 0.4 mm ( $1/64$  in.) in depth for vertical butt joints, vertically oriented permanent attachments, attachment welds for nozzles, manholes, flush-type openings, and the inside shell-to-bottom welds. For horizontal butt joints, horizontally oriented permanent attachments, and annular-ring butt joints, the maximum permissible undercut is 0.8 mm ( $1/32$  in.) in depth.
- c) The frequency of surface porosity in the weld does not exceed one cluster (one or more pores) in any 100 mm (4 in.) of length, and the diameter of each cluster does not exceed 2.5 mm ( $3/32$  in.).
- d) The reinforcement of the welds on all butt joints on each side of the plate shall not exceed the following thicknesses:

Plate Thickness mm (in.)	Maximum Reinforcement Thickness mm (in.)	
	Vertical Joints	Horizontal Joints
$\leq 13$ ( $1/2$ )	2.5 ( $3/32$ )	3 ( $1/8$ )
$> 13$ ( $1/2$ ) to 25 (1)	3 ( $1/8$ )	5 ( $3/16$ )
$> 25$ (1)	5 ( $3/16$ )	6 ( $1/4$ )

The reinforcement need not be removed except to the extent that it exceeds the maximum acceptable thickness or unless its removal is required by 8.1.3.4 for radiographic examination.

**8.5.3** A weld that fails to meet the criteria given in 8.5.2 shall be reworked before hydrostatic testing as follows:

- a) Any defects shall be removed by mechanical means or thermal gouging processes. Arc strikes discovered in or adjacent to welded joints shall be repaired by grinding and rewelding as required. Arc strikes repaired by welding shall be ground flush with the plate.
- b) Rewelding is required if the resulting thickness is less than the minimum required for design or hydrostatic test conditions. All defects in areas thicker than the minimum shall be feathered to at least a 4:1 taper.
- c) The repair weld shall be visually examined for defects.

## **8.6 Vacuum Testing**

**8.6.1** Vacuum testing is performed using a testing box approximately 150 mm (6 in.) wide by 750 mm (30 in.) long with a clear window in the top, which provides proper visibility to view the area under examination. During testing, illumination shall be adequate for proper evaluation and interpretation of the test. The open bottom shall be sealed against the tank surface by a suitable gasket. Connections, valves, lighting and gauges, as required, shall be provided. A soap film solution or commercial leak detection solution, applicable to the conditions, shall be used.

**8.6.2** Vacuum testing shall be performed in accordance with a written procedure prepared by the Manufacturer of the tank. The procedure shall require:

- a) performing a visual examination of the bottom and welds prior to performing the vacuum-box test;
  - b) verifying the condition of the vacuum box and its gasket seals;
  - c) verifying that there is no quick bubble or spitting response to large leaks; and
  - d) applying the film solution to a dry area, such that the area is thoroughly wetted and a minimum generation of application bubbles occurs.
- **8.6.3** A partial vacuum of 21 kPa (3 lbf/in.<sup>2</sup>, 6 in. Hg) to 35 kPa (5 lbf/in.<sup>2</sup>, 10 in. Hg) gauge shall be used for the test. If specified by the Purchaser, a second partial vacuum test of 56 kPa (8 lbf/in.<sup>2</sup>, 16 in. Hg) to 70 kPa (10 lbf/in.<sup>2</sup>, 20 in. Hg) shall be performed for the detection of very small leaks.

**8.6.4** The Manufacturer shall determine that each vacuum-box operator meets the following requirements:

- a) has vision (with correction, if necessary) to be able to read a Jaeger Type 2 standard chart at a distance of not less than 300 mm (12 in.). Operators shall be checked annually to ensure that they meet this requirement; and
- b) is competent in the technique of the vacuum-box testing, including performing the examination and interpreting and evaluating the results; however, where the examination method consists of more than one operation, the operator performing only a portion of the test need only be qualified for that portion the operator performs.

**8.6.5** The vacuum-box test shall have at least 50 mm (2 in.) overlap of previously viewed surface on each application.

**8.6.6** The metal surface temperature limits shall be between 4 °C (40 °F) and 52 °C (125 °F), unless the film solution is proven to work at temperatures outside these limits, either by testing or Manufacturer's recommendations.

**8.6.7** A minimum light intensity of 1000 Lux (100 fc) at the point of examination is required during the application of the examination and evaluation for leaks.

**8.6.8** The vacuum shall be maintained for the greater of either at least 5 seconds or the time required to view the area under test.

**8.6.9** The presence of a through-thickness leak indicated by continuous formation or growth of a bubble(s) or foam, produced by air passing through the thickness, is unacceptable. The presence of a large opening leak, indicated by a quick bursting bubble or spitting response at the initial setting of the vacuum box is unacceptable. Leaks shall be repaired and retested.

- **8.6.10** A record or report of the test including a statement addressing temperature and light intensity shall be completed and furnished to the Purchaser upon request.
- **8.6.11** As an alternate to vacuum-box testing, a suitable tracer gas and compatible detector can be used to test the integrity of welded bottom joints for their entire length. Where tracer gas testing is employed as an alternate to vacuum-box testing, it shall meet the following requirements:
  - a) Tracer gas testing shall be performed in accordance with a written procedure which has been reviewed and approved by the Purchaser and which shall address as a minimum: the type of equipment used, surface cleanliness, type of tracer gas, test pressure, soil permeability, soil moisture content, satisfactory verification of the extent of tracer gas permeation, and the method or technique to be used including scanning rate and probe standoff distance.
  - b) The technique shall be capable of detecting leakage of  $1 \times 10^{-4}$  Pa m<sup>3</sup>/s ( $1 \times 10^{-3}$  std cm<sup>3</sup>/s) or smaller.
  - c) The test system parameters (detector, gas, and system pressure, i.e., level of pressure under bottom) shall be calibrated by placing the appropriate calibrated capillary leak, which will leak at a rate consistent with (b) above, in a temporary or permanent fitting in the tank bottom away from the tracer gas pressurizing point. Alternatively, by agreement between the Purchaser and the Manufacturer, the calibrated leak may be placed in a separate fitting pressurized in accordance with the system parameters.
  - d) While testing for leaks in the welded bottom joints, system parameters shall be unchanged from those used during calibration.