Table 341.3.2  Acceptance Criteria for Welds and Examination Methods for Evaluating Weld Imperfections (Cont’d)

NOTES:

(1) Criteria given are for required examination. More stringent criteria may be specified in the engineering design. See also paras. 341.5 and 341.5.3.

(2) Longitudinal groove weld includes straight and spiral seam. Criteria are not intended to apply to welds made in accordance with a standard listed in Table A-1 or Table 326.1. Alternative Leak Test requires examination of these welds; see para. 345.9.

(3) Fillet weld includes socket and seal welds, and attachment welds for slip-on flanges, branch reinforcement, and supports.

(4) Branch connection weld includes pressure containing welds in branches and fabricated laps.

(5) These imperfections are evaluated only for welds ≤ 5 mm (1/16 in.) in nominal thickness.

(6) Where two limiting values are separated by “and,” the lesser of the values determines acceptance. Where two sets of values are separated by “or,” the larger value is acceptable. \( T_w \) is the nominal wall thickness of the thinner of two components joined by a butt weld.

(7) Tightly butted unfused root faces are unacceptable.

(8) For groove welds, height is the lesser of the measurements made from the surfaces of the adjacent components; both reinforcement and internal protrusion are permitted in a weld. For fillet welds, height is measured from the theoretical throat, Fig. 328.5.2A; internal protrusion does not apply.

(9) For welds in aluminum alloy only, internal protrusion shall not exceed the following values:
   - (a) for thickness ≤ 2 mm (1/16 in.): 1.5 mm (1/32 in.);
   - (b) for thickness > 2 mm and ≤ 6 mm (1/4 in.): 2.5 mm (1/16 in.).

For external reinforcement and for greater thicknesses, see the tabulation for Symbol L.

341.3.2, for Category D fluid service, unless otherwise specified.

341.4.3 Examination — Severe Cyclic Conditions. Piping to be used under severe cyclic conditions shall be examined to the extent specified herein or to any greater extent specified in the engineering design. Acceptance criteria are as stated in para. 341.3.2 and in Table 341.3.2, for severe cyclic conditions, unless otherwise specified.

(a) Visual Examination. The requirements of para. 341.4.1(a) apply with the following exceptions.

(1) All fabrication shall be examined.

(2) All threaded, bolted, and other joints shall be examined.

(3) All piping erection shall be examined to verify dimensions and alignment. Supports, guides, and points of cold spring shall be checked to ensure that movement of the piping under all conditions of startup, operation, and shutdown will be accommodated without undue binding or unanticipated constraint.

(b) Other Examination. All circumferential butt and miter groove welds and all fabricated branch connection welds comparable to those shown in Fig. 328.5.4E shall be examined by 100% radiography in accordance with para. 344.5, or (if specified in the engineering design) by 100% ultrasonic examination in accordance with para. 344.6. Socket welds and branch connection welds which are not radiographed shall be examined by magnetic particle or liquid penetrant methods in accordance with para. 344.3 or 344.4.

(c) In-process examination in accordance with para. 344.7, supplemented by appropriate nondestructive examination, may be substituted for the examination required in (b) above on a weld-for-weld basis if specified in the engineering design or specifically authorized by the Inspector.

(d) Certification and Records. The requirements of para. 341.4.1(c) apply.

341.5 Supplementary Examination

Any of the methods of examination described in para. 344 may be specified by the engineering design to supplement the examination required by para. 341.4. The extent of supplementary examination to be performed and any acceptance criteria that differ from those in para. 341.3.2 shall be specified in the engineering design.

341.5.1 Spot Radiography

(a) Longitudinal Welds. Spot radiography for longitudinal groove welds required to have a weld joint factor \( E_j \) of 0.90 requires examination by radiography in accordance with para. 344.5 of at least 300 mm (1 ft) in each 30 m (100 ft) of weld for each welder or welding operator. Acceptance criteria are as stated in Table 341.3.2 for radiography under Normal Fluid Service.

(b) Circumferential Butt Welds and Other Welds. It is recommended that the extent of examination be not less than one shot on one in each 20 welds for each welder or welding operator. Unless otherwise specified, acceptance criteria are as stated in Table 341.3.2 for radiography under Normal Fluid Service for the type of joint examined.

(c) Progressive Sampling for Examination. The provisions of para. 341.3.4 are applicable.

(d) Welds to Be Examined. The locations of welds and the points at which they are to be examined by spot
Fig. 341.3.2 Typical Weld Imperfections

(a) Side Wall Lack of Fusion

(b) Lack of Fusion Between Adjacent Passes

(c) Incomplete Penetration due to Internal Misalignment

(d) Incomplete Penetration of Weld Groove

(e) Concave Root Surface (Suck-Up)

(f) Undercut

(g) Excess External Reinforcement
radiography shall be selected or approved by the Inspector.

341.5.2 Hardness Tests. The extent of hardness testing required shall be in accordance with para. 331.1.7 except as otherwise specified in the engineering design.

341.5.3 Examinations to Resolve Uncertainty. Any method may be used to resolve doubtful indications. Acceptance criteria shall be those for the required examination.

342 EXAMINATION PERSONNEL

342.1 Personnel Qualification and Certification

Examiners shall have training and experience commensurate with the needs of the specified examinations. The employer shall certify records of the examiners employed, showing dates and results of personnel qualifications, and shall maintain them and make them available to the Inspector.

342.2 Specific Requirement

For in-process examination, the examinations shall be performed by personnel other than those performing the production work.

343 EXAMINATION PROCEDURES

Any examination shall be performed in accordance with a written procedure that conforms to one of the methods specified in para. 344, including special methods (see para. 344.1.2). Procedures shall be written as required in the BPV Code, Section V, Article 1, T-150. The employer shall certify records of the examination procedures employed, showing dates and results of procedure qualifications, and shall maintain them and make them available to the Inspector.

344 TYPES OF EXAMINATION

344.1 General

344.1.1 Methods. Except as provided in para. 344.1.2, any examination required by this Code, by the engineering design, or by the Inspector shall be performed in accordance with one of the methods specified herein.

344.1.2 Special Methods. If a method not specified herein is to be used, it and its acceptance criteria shall be specified in the engineering design in enough detail to permit qualification of the necessary procedures and examiners.

344.3 Definitions. The following terms apply to any type of examination:

- **100% examination**: complete examination of all of a specified kind of item in a designated lot of piping.
- **random examination**: complete examination of a percentage of a specified kind of item in a designated lot of piping.
- **spot examination**: a specified partial examination of each of a specified kind of item in a designated lot of piping, e.g., of part of the length of all shop-fabricated welds in a lot of jacketed piping.
- **random spot examination**: a specified partial examination of a percentage of a specified kind of item in a designated lot of piping.

344.2 Visual Examination

344.2.1 Definition. Visual examination is observation of the portion of components, joints, and other piping elements that are or can be exposed to view before, during, or after manufacture, fabrication, assembly, erection, examination, or testing. This examination includes verification of Code and engineering design requirements for materials, components, dimensions, joint preparation, alignment, welding, bonding, brazing, bolting, threading, or other joining method, supports, assembly, and erection.

344.2.2 Method. Visual examination shall be performed in accordance with the BPV Code, Section V, Article 9. Records of individual visual examinations are not required, except for those of in-process examination as specified in para. 344.7.

344.3 Magnetic Particle Examination

Examination of castings is covered in para. 302.3.3. Magnetic particle examination of welds and of components other than castings shall be performed in accordance with BPV Code, Section V, Article 7.

344.4 Liquid Penetrant Examination

Examination of castings is covered in para. 302.3.3. Liquid penetrant examination of welds and of components other than castings shall be performed in accordance with BPV Code, Section V, Article 6.

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1 For this purpose, SNT-TC-1A, Recommended Practice for Nondestructive Testing Personnel Qualification and Certification, may be used as a guide.

2 A designated lot is that quantity of piping to be considered in applying the requirements for examination in this Code. The quantity or extent of a designated lot should be established by agreement between the contracting parties before the start of work. More than one kind of designated lot may be established for different kinds of piping work.

3 Random or spot examination will not ensure a fabrication product of a prescribed quality level throughout. Items not examined in a lot of piping represented by such examination may contain defects which further examination could disclose. Specifically, if all radiographically detectable weld defects must be eliminated from a lot of piping, 100% radiographic examination must be specified.
344.5 Radiographic Examination

344.5.1 Method. Radiography of castings is covered in para. 302.3.3; other product forms are not covered. Ultrasonic examination of welds shall be performed in accordance with BPV Code, Section V, Article 5, except that the alternative specified in (a) and (b) below is permitted for basic calibration blocks specified in T-542.2.1 and T-542.8.1.1.

(a) When the basic calibration blocks have not received heat treatment in accordance with T-542.1.1(c) and T-542.8.1.1, transfer methods shall be used to correlate the responses from the basic calibration block and the component. Transfer is accomplished by noting the difference between responses received from the same reference reflector in the basic calibration block and in the component and correcting for the difference.

(b) The reference reflector may be a V-notch (which must subsequently be removed), an angle beam search unit acting as a reflector, or any other reflector which will aid in accomplishing the transfer.

(c) When the transfer method is chosen as an alternative, it shall be used, at the minimum:

(1) for sizes ≤ DN 50 (NPS 2), once in each 10 welded joints examined

(2) for sizes > DN 50 and ≤ DN 450 (NPS 18), once in each 1.5 m (5 ft) of welding examined

(3) for sizes > DN 450, once for each welded joint examined

(d) Each type of material and each size and wall thickness shall be considered separately in applying the transfer method. In addition, the transfer method shall be used at least twice on each type of weld joint.

(e) The reference level for monitoring discontinuities shall be modified to reflect the transfer correction when the transfer method is used.

344.5.2 Extent of Radiography

(a) 100% Radiography. This applies only to girth and miter groove welds and to fabricated branch connection welds comparable to Fig. 328.5.4E, unless otherwise specified in the engineering design.

(b) Random Radiography. This applies only to girth and miter groove welds.

(c) Spot Radiography. This requires a single exposure radiograph in accordance with para. 344.1 at a point within a specified extent of welding. For girth, miter, and branch groove welds the minimum requirement is

(1) for sizes ≤ DN 65 (NPS 2½), a single elliptical exposure encompassing the entire weld circumference

(2) for sizes > DN 65, the lesser of 25% of the inside circumference or 152 mm (6 in.)

For longitudinal welds the minimum requirement is 152 mm (6 in.) of weld length.

344.6 Ultrasonic Examination

344.6.1 Method. Examination of castings is covered in para. 302.3.3; other product forms are not covered. Ultrasonic examination of welds shall be performed in accordance with BPV Code, Section V, Article 5, except that the alternative specified in (a) and (b) below is permitted for basic calibration blocks specified in T-542.2.1 and T-542.8.1.1.

(a) When the basic calibration blocks have not received heat treatment in accordance with T-542.1.1(c) and T-542.8.1.1, transfer methods shall be used to correlate the responses from the basic calibration block and the component. Transfer is accomplished by noting the difference between responses received from the same reference reflector in the basic calibration block and in the component and correcting for the difference.

(b) The reference reflector may be a V-notch (which must subsequently be removed), an angle beam search unit acting as a reflector, or any other reflector which will aid in accomplishing the transfer.

(c) When the transfer method is chosen as an alternative, it shall be used, at the minimum:

(1) for sizes ≤ DN 50 (NPS 2), once in each 10 welded joints examined

(2) for sizes > DN 50 and ≤ DN 450 (NPS 18), once in each 1.5 m (5 ft) of welding examined

(3) for sizes > DN 450, once for each welded joint examined

(d) Each type of material and each size and wall thickness shall be considered separately in applying the transfer method. In addition, the transfer method shall be used at least twice on each type of weld joint.

(e) The reference level for monitoring discontinuities shall be modified to reflect the transfer correction when the transfer method is used.

344.6.2 Acceptance Criteria. A linear-type discontinuity is unacceptable if the amplitude of the indication exceeds the reference level and its length exceeds:

(a) 6 mm (¼ in.) for \( T_w \leq 19 \text{ mm (} 3⁄4 \text{ in.)} \)

(b) \( T_w/3 \) for 19 mm < \( T_w \leq 57 \text{ mm (2} 1⁄4 \text{ in.)} \)

(c) 19 mm for \( T_w > 57 \text{ mm} \)

344.7 In-Process Examination

344.7.1 Definition. In-process examination comprises examination of the following, as applicable:

(a) joint preparation and cleanliness

(b) preheating

(c) fit-up, joint clearance, and internal alignment prior to joining

(d) variables specified by the joining procedure, including filler material

(1) (for welding) position and electrode

(2) (for brazing) position, flux, brazing temperature, proper wetting, and capillary action

(e) (for welding) condition of the root pass after cleaning — external and, where accessible, internal — aided by liquid penetrant or magnetic particle examination when specified in the engineering design

(f) (for welding) slag removal and weld condition between passes

(g) appearance of the finished joint

344.7.2 Method. The examination is visual, in accordance with para. 344.2, unless additional methods are specified in the engineering design.

345 TESTING

345.1 Required Leak Test

Prior to initial operation, and after completion of the applicable examinations required by para. 341, each piping system shall be tested to ensure tightness. The test shall be a hydrostatic leak test in accordance with para. 345.4 except as provided herein.

(a) At the owner’s option, a piping system in Category D fluid service may be subjected to an initial service leak test in accordance with para. 345.7, in lieu of the hydrostatic leak test.

(b) Where the owner considers a hydrostatic leak test impracticable, either a pneumatic test in accordance with para. 345.5 or a combined hydrostatic-pneumatic test in accordance with para. 345.6 may be substituted, recognizing the hazard of energy stored in compressed gas.

(c) Where the owner considers both hydrostatic and pneumatic leak testing impracticable, the alternative specified in para. 345.9 may be used if both of the following conditions apply: