Use and misuse of ASME CODE CASE 2235-9

Foreword

Some years ago Asme Code has introduced the possibility to substitute the Radiography by Mechanized Ultrasonic Inspection of welds from the minimum thickness of 13 mm and on.

The fact that the possibility is still limited in a Code Case, apart from Section VIII Div. II were is now covered under chapter 7, gives the idea that the problem is still under careful examination. Too often the document is interpreted by the Inspection Agencies or clients with original approach, causing lot of problems to the Manufacturer of pressure vessels that do not find a well defined position in the code that can help to interpret the document.

Present paper takes into consideration some applications were many Manufacturers after a period of enthusiasm for the possibility to get rid of Radiation with all the annexed problems, having the possibility to give more complete information on the results of an inspection, using the most recent equipment available, are now considering to come back to the old Radiography.

Some points that give raise to more frequent dispute are here reported; for easy presentation the original text is reported and some comments are associated for consideration and possible discussion from the audience.

The conclusion is that it is easier to discuss and to obtain the approval of the Radiography system even if the results obtainable with ultrasonics are more complete and precise.

The situation

In principle the Code Case states that UT is accepted in lieu of radiography starting from thicknesses of 13 mm and over, provided that (only the most important items for our scope are reported here, toghether with short comments):

(a) The ultrasonic examination area shall include the volume of the weld, plus 2 in. (50 mm) on each side of the weld for material thickness greater than 8 in. (200 mm). For material thickness 8 in. (200 mm) or less, the ultrasonic examination area shall include the volume of the weld, plus the lesser of 1 in. (25 mm) or t on each side of the weld. Alternatively, examination volume may be reduced to include the actual heat affected zone (HAZ) plus 3/4 in. (6 mm) of base material beyond the heat affected zone on each side of the weld, provided the following requirements are met:

(1) The extent of the weld HAZ is measured and documented during the weld qualification process.

(2) The ultrasonic (UT) transducer positioning and scanning device is controlled using a reference mark (paint or low stress stamp adjacent to the weld) to ensure that the actual HAZ plus an additional 3/4 in. (6 mm) of base metal is examined.
(b) A documented examination strategy or scan plan shall be provided showing transducer placement, movement, and component coverage that provides a standardized and repeatable methodology for weld acceptance. The scan plan shall also include ultrasonic beam angle used, beam directions with respect to weld centerline, and vessel volume examined for each weld. The documentation shall be made available to the Owner/User upon request.

(c) The ultrasonic examination shall be performed in accordance with a written procedure conforming to the requirements of Section V, Article 4. The procedure shall have been demonstrated to perform acceptably on a qualification block(s). The qualification block(s) shall be prepared by welding or the hot isostatic process (HIP) and shall contain a minimum of three flaws, oriented to simulate flaws parallel to the production weld's fusion line as follows:

1. one surface flaw on the side of the block representing the vessel OD surface
2. one surface flaw on the side of the block representing the vessel ID surface
3. one subsurface flaw
4. If the block can be flipped during UT examination, then one flaw may represent both the ID and OD surfaces. Thus only two flaws may be required.

Flaw size shall be no larger than the flaw in Table 1, 2, or 3 for the thickness to be examined. Acceptable performance is defined as response from the maximum allowable flaw and other flaws of interest demonstrated to exceed the reference level. Alternatively, for techniques that do not use amplitude recording levels, acceptable performance is defined as demonstrating that all imaged flaws with recorded lengths, including the maximum allowable flaws, have an indicated length equal to or greater than the actual length of the flaws in the qualification block.

(d) The ultrasonic examination shall be performed using a device employing automatic computer-based data acquisition. The initial straight beam material examination (T-472 of Section V, Article 4) for reflectors that could interfere with the angle beam examination shall be performed (1) manually, (2) as part of a previous manufacturing process, or (3) during the automatic UT examination provided detection of these reflectors is demonstrated [subpara. (c)].

(e) Data is recorded in unprocessed form. A complete data set with no gating, filtering, or thresholding for response from examination volume in para. (a) above shall be included in the data record.

In this case the thickness of defect need not to be measured? What about the position?

In case of Tofd technique what to do for defects close to surface? This apply also for C-B scan and phased array.
(f) Personnel performing and evaluating UT examinations shall be qualified and certified in accordance with their employer's written practice. ASNT SNT-TC-1A or CP-189 shall be used as a guideline. Only Level II or III personnel shall analyze the data or interpret the results.

(g) Contractor qualification records of certified personnel shall be approved by the Certificate Holder and maintained by their employer.

(h) In addition, personnel who acquire and analyze UT data shall be trained using the equipment in (d) above, and participate in the demonstration of (e) above.

(i) Data analysis and acceptance criteria shall be as follows:

1. Data Analysis Criteria. Reflectors exceeding the limits in either (a) or (b) below, as applicable, shall be investigated to determine whether the indication originates from a flaw or is a geometric indication in accordance with para. (i)(2) below. When a reflector is determined to be a flaw, it shall be evaluated for acceptance in accordance with para. (i)(4). Flow Evaluation and Acceptance Criteria.

(a) For amplitude-based techniques, the location, amplitude, and extent of all reflectors that produce a response greater than 20% of the reference level shall be investigated.

(b) For nonamplitude-based techniques, the location and extent of all images that have an indicated length greater than the limits in (1), (2), or (3) below, as applicable, shall be investigated.

1. For welds in material equal to or less than 1\(\frac{1}{2}\) in. (38 mm) thick at the weld, images with indicated lengths greater than 0.150 in. (3.8 mm) shall be investigated.

2. For welds in material greater than 1\(\frac{1}{2}\) in. (38 mm) thick but less than 4 in. (100 mm) thick at the weld, images with indicated lengths greater than 0.200 in. (5 mm) shall be investigated.

3. For welds in material greater than 4 in. (100 mm) thick at the weld, images with indicated lengths greater than 0.050 in. (0.75 mm) (19 mm), whichever is smaller, shall be investigated (\(t = \) nominal material thickness adjacent to the weld).
(2) Geometric. Ultrasonic indications of geometric and metallurgical origin shall be classified as follows:

(a) Indications that are determined to originate from the surface configurations (such as weld reinforcement or root geometry) or variations in metallurgical structure of materials (such as cladding to base metal interface) may be classified as geometric indications, and

(1) need not be characterized or sized in accordance with (i)(3) below:

(2) need not be compared to allowable flaw acceptance criteria of Table 1, 2, or 3;

(3) the maximum indication amplitude and location shall be recorded, for example: internal attachments, 200% DAC maximum amplitude, one (1) in. (25 mm) above the weld centerline, on the inside surface, from 90 to 95 deg.

(b) The following steps shall be taken to classify an indication as geometric:

(i) Interpret the area containing the reflector in accordance with the applicable examination procedure;

(ii) Plot and verify the reflector coordinates, provide a cross-sectional display showing the reflector position and surface discontinuity such as root or counterbore;

(iii) Review fabrication or weld prep drawings.

(c) Alternatively, other NDE methods or techniques may be applied to classify an indication as geometric (e.g., alternative UT beam angles, radiography, ID and/or OD profiling).

Difficult to interpret, come back to radiography?

(3) Flaw Sizing. Flaws shall be sized in accordance with a procedure demonstrated to size similar flaws at similar material depths. Alternatively, a flaw may be sized by a supplemental manual technique so long as it has been qualified by the demonstration above. The dimensions of the flaw shall be determined by the rectangle that fully contains the area of the flaw. (Refer to Figs. 1–5.)

(a) The length (L) of the flaw shall be drawn parallel to the inside pressure-retaining surface of the component.

(b) The depth of the flaw shall be drawn normal to the inside pressure retaining surface and shall be denoted as “a” for a surface flaw or “2a” for a subsurface flaw.

Difficult to evaluate and not automatically recorded in unprocessed way

(4) Flaw Evaluation and Acceptance Criteria. Flaws shall be evaluated for acceptance using the applicable criteria of Table 1, 2, or 3 and with the following additional requirements:
The three NDT systems considered do not detect the depth of a defect with the precision requested.

(a) Surface Connected Flaws. Flaws identified as surface flaws during the UT examination may or may not be surface connected. Therefore, unless the UT data analysis confirms that that flaw is not surface connected, it shall be considered surface connected or a flaw open to the surface, and is unacceptable unless a surface examination is performed in accordance with (1), (2), or (3) below. If the flaw is surface connected, the requirements above still apply; however, in no case shall the flaw exceed the acceptance criteria in the applicable Construction Code for the method employed.

Acceptable surface examination techniques are:

(1) Magnetic particle examination (MT) in accordance with Appendix 6 of Section VIII, Division 1; Appendix 9-1 of Section VIII, Division 2; Appendix A-260 of Section I as applicable; or Appendix V of Section XII, or

(2) Liquid penetrant examination (PT) in accordance with Appendix 8 of Section VIII, Division 1; Appendix 9-2 of Section VIII, Division 2; Appendix A-270 of Section I as applicable; or Appendix VI of Section XII, or

(3) Eddy current examination (ET) in accordance with Supplement I of this Case. All relevant ET indications that are open to the surface are unacceptable regardless of length.

(b) Multiple Flaws

(1) Discontinuous flaws shall be considered a singular planar flaw if the distance between adjacent flaws is equal to or less than S as shown in Fig. 2.

(2) Discontinuous flaws that are oriented primarily in parallel planes shall be considered a singular planar flaw if the distance between the adjacent planes is equal to or less than \( \frac{1}{2} \) in. (13 mm). (Refer to Fig. 3.)

(3) Discontinuous flaws that are coplanar and nonaligned in the through-wall thickness direction of the component shall be considered a singular planar flaw if the distance between adjacent flaws is equal to or less than S as shown in Fig. 4.

(4) Discontinuous flaws that are coplanar in the through-wall direction with two parallel planes \( \frac{1}{2} \) in. (13 mm) apart (i.e., normal to the pressure-retaining surface of the component) are unacceptable if the additive
Elements for consideration

On the basis of the above simple considerations it appears that, after long time, the problem of accepting UT in Lieu of RT is still in a discussion stage and that the acceptance of any system is still depending from the Company requesting the inspection and from the mood of the Inspector or Third Party Agency Representative. The demonstration of satisfactory performance is very difficult, when inspecting pipes of large thicknesses (more than 50 mm) and small diameters, particularly in Pipe-to Flange or Pipe to Elbow connections.

In some cases Inspectors from well known Companies have requested the validation of the system by means of blind tests performed on samples specifically prepared to verify the detection of artificial reflectors that for their nature and position would not normally be encountered in practice.

In other cases a modelling of scan plan prepared to detect, in the most unfavorable condition, the maximum defect to be found, were preliminary evaluated in terms of probability of detection by software, obtaining even different results from the ones used from two different Inspection Agencies.

The conclusion is that more and more Constructors prefer to come back to RT inspection for big thicknesses because what can be seen is often very poor and do not give raise to endless dispute.