

Annex U (normative)

Ultrasonic Examination in Lieu of Radiography

U.1 General

U.1.1 Purpose

This Annex provides detailed rules for the use of the ultrasonic examination (UT) method for the examination of tank seams as permitted by 7.3.2.1. This alternative is limited to joints where the thickness of the thinner of the two members joined is greater than or equal to 6 mm ($1/4$ in.).

U.1.2 Application and Extent

The provisions of 8.1 governing:

- a) when adjacent plates may be regarded as the same thickness;
- b) application (see 8.1.1); and
- c) number and Locations (see 8.1.2);

shall apply to this ultrasonic method. When these sections refer to radiography, for purposes of this Annex, they shall be read as applied to UT.

U.2 Definitions

U.2.1

documenting

Preparation of text and/or and figures.

U.2.2

evaluation

All activities required in U.6.3 through U.6.6 to determine the acceptability of a flaw.

U.2.3

flaw

A reflector that is not geometric or metallurgical in origin that may be detectable by nondestructive examination but is not necessarily rejectable.

U.2.4

flaw categorization

Whether a flaw is a surface flaw or is a subsurface flaw (see U.6.4). Note that a flaw need not be surface-breaking to be categorized as a surface flaw.

U.2.5

flaw characterization

The process of quantifying the size, location and shape of a flaw. See U.6.3 for size and location. The only shape characterization required by this Annex is applied to the results of supplemental surface examination by MT or PT (see U.6.6.2).

U.2.6**indication**

That which marks or denotes the presence of a reflector.

U.2.7**interpretation**

The determination of whether an indication is relevant or non-relevant. i.e. whether it originates from a geometric or metallurgical feature or conversely originates from a flaw (see U.6.2).

U.2.8**investigation**

Activities required to determine the interpretation of an indication (see U.6.1 and U.6.2).

U.2.9**recording**

The writing of ultrasonic data onto an appropriate electronic medium.

U.2.10**reflector**

An interface at which an ultrasonic beam encounters a change in acoustic impedance and at which at least part of the energy is reflected.

U.3 Technique

- **U.3.1** The UT volume shall include the weld metal, plus the lesser of 25 mm (1 in.) or t of adjoining base metal on each side of the weld unless otherwise agreed upon by the Purchaser and the Manufacturer.

U.3.2 UT for the detection of flaws shall be performed using automated, computer-based data acquisition except that initial scanning of adjacent base metal for flaws that can interfere with the automated examination may be performed manually. UT for sizing of flaws shall be performed as described in U.6.3.1

- **U.3.3** 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 to be used, beam directions with respect to weld centerline, and tank material volume examined for each weld. The documentation shall be made available to the Owner upon request.

U.3.4 Data from the examination volume, per U.3.1, shall be recorded and/or documented as follows:

a) For automated computer-based scans, data shall be recorded using the same system essential variables, specified value or range of values, used for the demonstration of the procedure per U.4.3.

b) For manual scans, results shall be documented in a written report.

- **U.3.5** The UT shall be performed in accordance with a written procedure which has been reviewed and approved by the Purchaser and conforms to the requirements of ASME Section V, Article 4, except that:

a) the calibration block shown in Figure T-434.2.1 of ASME Section V, Article 4 shall be used for distance amplitude (e.g. pulse-echo) techniques, and Figure III-434.2.1 (a) or (b) shall be used for non-distance amplitude [e.g. Time of Flight Diffraction (TOFD) examination] techniques,

b) for examination techniques that provide plate quality information (e.g. TOFD), the initial base material straight-beam examination need not be performed.

U.3.6 The examination methodology (including U.6.6) shall be demonstrated to be effective over the full weld volume. It is recognized that TOFD may have limitations in detection of flaws at the surface such that it may be necessary to supplement TOFD with pulse-echo techniques suitable for the detection of near-field and far-field flaws. The variety of surface and sub-surface category flaws in the test plate mandated by U.4.3a are intended to ensure that any such limitations are adequately addressed.

U.4 Personnel Qualifications and Training

U.4.1 Personnel Qualifications—Personnel performing and evaluating UT examinations shall be qualified and certified in accordance with their employer's written practice. ASNT SNT-TC-IA, CP-189, or ISO Std 9712 shall be used as a guideline. Only Level-II or Level-III personnel shall perform UT examinations, analyze the data, or interpret the results.

U.4.2 Qualification Records—Qualification records of certified personnel shall be approved by the Manufacturer and maintained by their employer.

- **U.4.3 Personnel Testing**—Personnel who acquire and analyze UT data shall be trained using the equipment of U.3.2, and the procedure of U.3.5 above. Additionally, they shall pass a practical examination based on the technique on a blind test plate. The testing program details shall be by agreement between the Purchaser and the inspection company but shall in any case include the following elements as a minimum.

- a) The test plate shall contain a variety of surface and sub-surface category flaws including multiple flaws described in U.6.5. Some of the flaws shall be acceptable and others unacceptable per the applicable criteria of Table U.1a or Table U.1b.
- b) The practical examination should cover detection, interpretation, sizing, plotting, categorization, grouping, and characterization that is sufficient to cover the cases outlined in U.6.
- c) Criteria for passing the test shall include limits on the number of miscalls, both of rejectable flaws missed or accepted and acceptable regions rejected.
- d) Testing shall be facilitated by a third-party or by the Purchaser.

U.5 Level III Review

U.5.1 The final data package shall be reviewed by a UT Level-III individual qualified in accordance with U.4.1 and U.4.3 above. The review shall include the following.

- a) The ultrasonic data record.
- b) Data interpretations.
- c) Evaluations of indications performed by another qualified Level-II or Level-III individual. The data review may be performed by another individual from the same organization.

U.5.2 Alternatively, the review may be achieved by arranging for a data acquisition and initial interpretation by a Level-II individual qualified in accordance with U.4.1 and U.4.3 above, and a final interpretation and evaluation shall be performed by a Level-III individual qualified per U.5.1.

U.6 Interpretation and Evaluation

U.6.1 Investigation Criteria—Reflectors that produce a response greater than 20 % of the reference level shall be investigated. Alternatively, for methods or techniques that do not use amplitude recording levels, sized reflectors longer than 40 % of the acceptable surface or subsurface flaws in Table U.1a and Table U.1b shall be investigated.

The investigation shall interpret whether the indication originates from a flaw or is a geometric indication in accordance with U.6.2 below. When the reflector is determined to be a flaw, the flaw shall be evaluated and acceptance criteria of Table U.1a and Table U.1b as applicable shall apply.

U.6.2 Interpretation as Geometric/Metallurgical—Ultrasonic indications of geometric and metallurgical origin shall be interpreted as follows:

U.6.2.1 Indications that are determined to originate from the surface configurations (such as weld reinforcement or root geometry) or variations in metallurgical structure of materials may be interpreted as geometric indications, and

- a) need not be sized or categorized in accordance with U.6.3 and U.6.4 below;
- b) need not be compared to the allowable flaw acceptance criteria of Table U.1a and Table U.2b; and
- c) the maximum indication amplitude (if applicable) and location shall be documented, for example: internal attachments, 200 % DAC maximum amplitude, 1 in. above the weld centerline, on the inside surface, from 90° to 95°.

U.6.2.2 The following steps shall be taken to classify an indication as geometric.

- a) Interpret the area containing the indication in accordance with the applicable examination procedure.
- b) Plot and verify the indication's coordinates, provide a cross-sectional display showing the indication's position and any surface conditions such as root or counter-bore.
- c) Review fabrication or weld prep drawings.

U.6.2.3 Alternatively, other NDE methods or techniques may be applied to interpret an indication as geometric (e.g., alternative UT beam angles, radiography, ID and/or OD profiling).

U.6.3 Flaw Sizing

U.6.3.1 Flaws shall be sized using automated, computer-based data acquisition or by a supplemental manual technique that has been demonstrated to perform acceptably per U.4.3.

U.6.3.2 The dimensions of the flaw shall be defined by the rectangle that fully contains the area of the flaw. The length (l) of the flaw shall be drawn parallel to the inside pressure-retaining surface of the component. The height (h) of the flaw shall be drawn normal to the inside pressure-retaining surface.

U.6.4 Flaw Categorization

If the space between the surface and the flaw in the through-thickness direction is less than one-half the measured height of the flaw, then the flaw shall be categorized as a surface flaw with flaw height extending to the surface of the material.

U.6.5 Grouping of Multiple Flaws

U.6.5.1 Discontinuous flaws that are oriented primarily in parallel planes shall be considered to lie in a single plane if the distance between the adjacent planes is equal to or less than 13 mm ($1/2$ in.).

U.6.5.2 If the space between two flaws aligned along the axis of weld is less than the length of the longer of the two, the two flaws shall be considered a single flaw.

U.6.5.3 If the space between two flaws aligned in the through-thickness direction is less than the height of the flaw of greater height, the two flaws shall be considered a single flaw.

U.6.6 Flaw Acceptance Criteria

U.6.6.1 Acceptance Criteria Tables—Flaw dimensions resulting after the application of the rules of U.6.3, U.6.4, and U.6.5 shall be evaluated for acceptance using the criteria of Table U.1a and Table U.1b.

U.6.6.2 Surface Examination—Flaws categorized as surface flaws during the UT examination may or may not be surface-connected. Therefore, unless the UT data analysis confirms that the flaw is not surface-connected, a supplemental surface examination (MT or PT) shall be performed in accordance with 8.2 or 8.4 as applicable for all surface flaws. Any flaws which are detected by MT or PT and characterized as planar are unacceptable regardless of length.

U.7 Repairs

All repaired areas, plus the lesser of 25 mm (1 in.) or t of the adjoining weld on each side of the repair, shall be reinspected per this Annex.

U.8 Flaw Documentation

In addition to the data record prescribed by U.3.4, written documentation shall be produced for each unacceptable flaw and those acceptable flaws that either exceed 50 % of reference level for amplitude based techniques or exceed 75 % of the acceptable length for non-amplitude techniques.

Table U.1a—Flaw Acceptance Criteria for UT Indications May be Used for All Materials (SI)

All dimensions in mm

Thickness at Weld (t) ^a	MAXIMUM ACCEPTABLE FLAW LENGTHS—(l)							
	For Surface Flaw ^b With Height, (h) No Greater Than			For SubSurface Flaw With Height, (h) No Greater Than				
	2.0	2.5	3.0	2.0	3.0	4.0	5.0	6.0
6 to < 10	8	4	3	5	3	Not allowed	Not allowed	Not allowed
10 to < 13	8	8	4	14	5	4	Not allowed	Not allowed
13 to < 19	8	8	4	38	8	5	4	3
19 to < 25	8	8	4	75	13	8	6	5
25 to < 32	9	8	4	100	20	9	8	6
32 to < 40	9	8	4	125	30	10	8	8
40 to < 44	9	8	4	150	38	10	9	8
^a t = thickness of the weld excluding any allowable reinforcement. For a butt weld joining members having different thickness at the weld, t is the thinner of the two. ^b Any surface flaw, to be deemed acceptable, must satisfy both the size limitations of this table and additionally satisfy the MT/PT characterization limitations of U.6.6.2								

Table U.1b—Flaw Acceptance Criteria for UT Indications May be Used for All Materials (USC)

All dimensions in inches

Thickness at Weld (<i>t</i>) ^a	MAXIMUM ACCEPTABLE FLAW LENGTHS—(<i>l</i>)							
	For Surface Flaw ^b With Height, (<i>h</i>) No Greater Than			For SubSurface Flaw With Height, (<i>h</i>) No Greater Than				
	0.08	0.10	0.12	0.08	0.12	0.16	0.2	0.24
0.25 < 0.375	0.30	0.15	0.12	0.20	0.12	Not allowed	Not allowed	Not allowed
0.375 to < 0.50	0.30	0.30	0.15	0.55	0.20	0.15	Not allowed	Not allowed
0.50 to < 0.75	0.30	0.30	0.15	1.50	0.30	0.20	0.15	0.10
0.75 to < 1.0	0.30	0.30	0.15	3.00	0.50	0.30	0.25	0.20
1.0 to < 1.25	0.35	0.30	0.15	4.00	0.80	0.35	0.30	0.25
1.25 to < 1.50	0.35	0.30	0.15	5.00	1.20	0.40	0.30	0.30
1.50 to < 1.75	0.35	0.30	0.15	6.00	1.50	0.40	0.35	0.30
^a <i>t</i> = thickness of the weld excluding any allowable reinforcement. For a butt weld joining members having different thickness at the weld, <i>t</i> is the thinner of the two. ^b Any surface flaw, to be deemed acceptable, must satisfy both the size limitations of this table and additionally satisfy the MT/PT characterization limitations of U.6.6.2.								