

SECTION 05 05 23.13 10

ULTRASONIC INSPECTION OF WELDMENTS  
08/18

PART 1 GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN WELDING SOCIETY (AWS)

AWS D1.1/D1.1M (2020; Errata 1 2021) Structural Welding  
Code - Steel

ARCHITECTURAL INSTITUTE OF JAPAN (AIJ)

JASS 6 (2015) Structural Steelwork Specification  
for Building Construction

JAPANESE STANDARDS ASSOCIATION (JSA)

JIS Z 2305 (2013) Non-destructive Testing -  
Qualification and Certification of  
Personnel

JIS Z 2345 (2015) Standard Test Blocks for Ultrasonic  
Testing

JIS Z 3060 (2015) Method of Ultrasonic Testing for  
Welds of Ferritic Steel

1.2 DEFINITIONS

1.2.1 A Scan

Method of data presentation on an electronic screen using rectangular coordinates in which a horizontal base line indicates elapsed time when reading from left to right. A vertical deflection in the base line indicates reflect signal amplitude.

1.2.2 Acoustically Similar Material

Material the same as that to be inspected; or another material proven to have acoustical velocity within plus or minus 3 percent and an attenuation within plus or minus 0.009843 dB/mm of the inspected material for the inspection frequency and wave mode, using the same mode as that to be used for inspection.

1.2.3 Amplitude

When referring to an indication in A scan presentation, amplitude is the vertical height of the indication measured from peak-to-peak for radio frequency indications and trace-to-peak for video indications.

#### 1.2.4 Attenuation

Dissipation or loss of energy as ultrasonic vibrations travel through the material. Attenuation is caused almost entirely by scattering of the ultrasonic vibrations generated by the search unit.

#### 1.2.5 Back Reflection or End Reflection

Reflection from the opposite side, end, or boundary of the material into which the ultrasonic energy was introduced.

#### 1.2.6 Calibration

Process of comparing an instrument or device with a standard to determine accuracy or produce a scale.

#### 1.2.7 Couplant

Any material, usually a liquid or semiliquid, used between the search unit and the inspection surface to exclude air and to convey the ultrasonic vibrations between the search unit and the material being inspected.

#### 1.2.8 Digital Display

Display capable of presenting multi-function a-scan, b-scan, c-scan or s-scan responses. This also includes instruments settings and parameters.

#### 1.2.9 Decibel (dB)

Units for the logarithmic expression of the ratio of power levels. Power levels can be functions of voltage, current, or impedance, for example. Decibel units having no values of their own are only significant when a reference is stated, as 10 dB above one reference level or 6 dB below another reference level.

#### 1.2.10 Discontinuity

Anything within a material that causes a detectable interruption in an ultrasonic beam.

#### 1.2.11 Examination

Within the context of this specification, examination is equivalent to the word "inspection."

#### 1.2.12 Hertz

One complete set of recurrent values of a periodic quantity comprises a cycle. In other words, any one set of periodic variations starting at one condition and returning once to the same condition is a cycle.

#### 1.2.13 Immersion Techniques

Test methods in which the part to be tested and the search units are immersed in water or other suitable liquid couplant. A mechanical device is used to firmly hold and direct the wave angle of the search unit. The search unit does not contact the item being inspected.

#### 1.2.14 Indication

Visual presentation on the digital display screen resulting from a sound beam reflection from a boundary surface or discontinuity.

#### 1.2.15 Linearity

Property of an instrument revealed by a linear change in reflected signal or displacement. The vertical linearity is determined by plotting the change in ratios of signal amplitude from two adjacent reflections from an area of known size. The horizontal linearity is determined by plotting the distance the signal is displaced along the sweep against the change in material thickness or by noting the spacing of multiple back reflections.

#### 1.2.16 Longitudinal or Compressional Waves

Simple compression-rarefaction waves in which particle motion within a material is linear and in the direction of wave propagation. Also called straight beams, or compressional or normal waves.

#### 1.2.17 Longitudinal Wave Inspection

Ultrasonic technique, normally using straight beam methods, in which longitudinal waves are the dominant form.

#### 1.2.18 Mid-Screen Reflection

Reflection whose amplitude is equal to one-half the useable screen height on the digital display.

#### 1.2.19 Megahertz (MHz)

One million hertz per second frequency.

#### 1.2.20 Pulse Repetition Rate

Number of spaced pulses of sound per second sent into the material being inspected.

#### 1.2.21 Reflector

Boundary, consisting of an opposite side, crack, or separation, or a distinct change in material such as slag or porosity that reflects the ultrasonic energy the same as a mirror reflects light.

#### 1.2.22 Refracted Waves

Waves that have undergone change of velocity and direction by passing from one material to another material with different acoustical properties. Refraction occurs wherever the angle of the incident wave to the interface is other than perpendicular.

#### 1.2.23 Resolution

Ability to clearly distinguish signals obtained from two reflective surfaces with a minimum separation distance. Near-surface resolution is the ability to clearly distinguish a signal from a reflector at a minimum distance under the contact or near surface without interference from the initial pulse signal. Far-surface resolution is the ability to clearly

distinguish signals from reflectors displaced at minimum distances from the far or back surface when the sound beam is normal to that back surface.

#### 1.2.24 Search Unit

Device containing a piezoelectric material used for introducing vibrations into a material to be inspected or for receiving the vibrations reflected from the material. The active element of the search unit is defined as the effective transmitting area. Search units are also called transducers or probes. They may be single or dual and contain one or two piezoelectric elements, respectively, for transmission and reception. The single search unit is sometimes enclosed in a transducer wheel or search unit wheel. The search unit may be manually handled and placed in direct contact with the material to be inspected or may be held in a fixture for immersion techniques.

#### 1.2.25 Sensitivity

Measure of the ultrasonic equipment's ability to detect discontinuities. Quantitatively, it is the level of amplification of the receiver circuit in the ultrasonic instrument necessary to produce the required indication on the scope from the reference hole in the reference block. Also see "Standard Reference Level."

#### 1.2.26 Shear Waves

Waves in which the particles within the material vibrate perpendicularly to the direction in which the wave travels or propagates. Also called transverse waves.

#### 1.2.27 Standard Reference Level

Mid-screen height reflection when beaming at the 1.50 mm hole in the primary reference block or the reference hole in the secondary standard.

### 1.3 SUBMITTALS

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

#### SD-01 Preconstruction Submittals

Personnel Qualification; G

Procedure description; G

#### SD-03 Product Data

Equipment and accessories

#### SD-06 Test Reports

Equipment Qualifications

Inspection Test Reports

## 1.4 QUALITY ASSURANCE

### 1.4.1 Personnel Qualification

The three levels of responsibility associated with ultrasonic inspection are defined in JIS Z 2305. Personnel performing NDT should be level II or Level I with direct supervision. For qualification to perform ultrasonic inspection, certify personnel in accordance with JIS Z 2305 within a period of 1 year before the date of contract. Submit inspector qualifications per JIS Z 2305. Other qualification or certification may be accepted at the Contracting Officer's discretion. Personnel with only an operator or inspector trainee certification will not be considered qualified to pass judgment on the acceptability of inspected items, but may work under the direct supervision of a qualified ultrasonic inspector. Qualified ultrasonic inspectors must be able to judge the acceptability of the item in accordance with paragraph ACCEPTANCE-REJECTION CRITERIA. Only serialized NIST traceable calibration standards are to be used. The procedures to be used for personnel and equipment qualification, equipment calibration, and inspection, at least 30 days prior to their intended use. Approval by the Government will in no way affect the obligation of the Contractor to employ qualified personnel, equipment, and procedures, and to perform the inspection as specified.

### 1.4.2 Examinations

If the Contracting Officer doubts an individual's ability as an operator, inspector, or supervisor, recertify the individual in accordance with JIS Z 2305, using the practical exam. At the option of the Government, the Contracting Officer may witness the examination and in evaluating the results.

### 1.4.3 Reference Standards

Use reference standards to calibrate the inspection equipment, test its operating condition, and record the sensitivity or response of the equipment during the inspection in accordance with paragraph EQUIPMENT QUALIFICATIONS. The standards comprise a standard reference block and reference specimens as noted below.

- a. Provide the standard reference block or primary standard consisting of the IIW block in AWS D1.1/D1.1M, Clause 6, Part F or JIS Z 2345. Also use the standard reference block in any reinspection on the same basis as the original inspection, even though the reinspection is to be performed by other ultrasonic instruments and accessories.
- b. As an option, use other recognized working standards detailed with the IIW block in AWS D1.1/D1.1M such as the Sensitivity Calibration (SC) block. However, reference such blocks to the IIW block as noted in paragraph EQUIPMENT CALIBRATION. Include details of their use in the submitted procedure description. These blocks are the secondary standards. They must be of acoustically similar material to the welds to be inspected. The secondary standards must be suited for the applicable tests specified in paragraph EQUIPMENT QUALIFICATIONS and are used as follows, except where the IIW block is specifically required:

- (1) To assure adequate penetration of the base material.

- (2) To provide a secondary field standard.
- (3) To calibrate the equipment and establish the standard reference level.

#### 1.4.4 Resolution Test Block

Furnish a resolution test block in accordance with the details shown in AWS D1.1/D1.1M, Clause 6, Part F or JIS Z 2345.

#### 1.4.5 Equipment Qualifications

Calibrate and recalibrate all NDT equipment in accordance with AWS D1.1/D1.1M requirements.

### PART 2 PRODUCTS

#### 2.1 SYSTEM DESCRIPTION

##### 2.1.1 Procedures and Methods

Use the pulse echo contact method with an A scan presentation for the ultrasonic inspection of welded joints, except that immersion techniques may be used for some applications when approved by the Contracting Officer. Use the procedures, methods, standards, and description of equipment specified herein for inspection of weldments. Include the following in the submitted procedure description:

- a. Couplant.
- b. Search unit characteristics including angle, size, shape, nominal frequency, type designation.
- c. Method and type of wave.
- d. Equipment and accessories including manufacturer, model number, date of manufacture, last date of calibration, and the manufacturer's electrical, physical, and performance specifications.
- e. Decibel (dB) compensation system for distance-amplitude correction.

##### 2.1.2 Wave Types

The types of waves and the conditions under which they are used are specified below. Unless conditions prohibit, use shear waves. A longitudinal wave procedure may be used instead, if approved by the Contracting Officer.

##### 2.1.2.1 Shear Waves

Use refracted waves between 40 degrees and 70 degrees except where different angles are indicated in approved procedures, such as for materials less than 13 mm thick, for materials with sound velocities greater than in steel, when the weldments are not readily accessible, or when existing backing rings or backing strips are not removed. For inspection of weldments containing backing rings or backing strips, adjust the instrument and select the refracted angles in a way to separate the weldment and the backing ring reflections. Establish the search unit angle and the resulting shear wave angle in the material to be inspected for each application and include this information in the procedure

submitted for approval.

#### 2.1.2.2 Longitudinal Waves

Specifically develop the procedure to suit the application and attain the prior approval of the Contracting Officer.

#### 2.1.3 Changes in Procedure

Should application of an approved procedure not provide for good resolution or adequate ultrasonic penetration in the items to be inspected (see paragraph EQUIPMENT QUALIFICATIONS), make changes in procedure or equipment such as frequency, pulse repetition rate, angle of search unit, couplant, or oscilloscope. Demonstrate adequacy of the new procedure to the Contracting Officer. The Government reserves the right to require a change in test equipment during these tests if any of the following test system characteristics fall below the levels listed in paragraph EQUIPMENT QUALIFICATIONS: sensitivity, amplitude and distance linearity, signal-to-noise ratio, entry and back surface resolution and penetration.

#### 2.1.4 Ultrasonic Equipment

Provide ultrasonic equipment conforming to the requirements listed in AWS D1.1/D1.1M Clause 6, Part F or JIS Z 3060, with the following exceptions:

- a. The ultrasonic test instruments must be able to generate, receive, and to present pulses in the frequency range from 1 to 10 megahertz (MHz).
- b. Measure the horizontal linearity of the ultrasonic instrument in accordance with paragraph EQUIPMENT QUALIFICATIONS.
- c. In addition to the resolution test specified in AWS D1.1/D1.1M, Clause 6, Part F or JIS Z 3060, conduct both near- and far-surface resolution tests in accordance with the tests specified for these characteristics in the paragraph EQUIPMENT QUALIFICATIONS.

### PART 3 EXECUTION

#### 3.1 PREPARATION OF MATERIALS FOR INSPECTION

Surfaces must be free of the following:

##### 3.1.1 Weld Spatter

Remove spattering or any roughness that interferes with free movement of the search unit or impairs transmission of the ultrasonic vibrations.

##### 3.1.2 Irregularities

Those which could mask or be confused with defect indications.

##### 3.1.3 Weld Backing Strips

Remove strips that are not to remain in place and eliminate all sharp edges and valleys by grinding or other mechanical means.

#### 3.1.4 Dirt

Remove all loose scale, rust, paint, and dirt from the coupling surface.

### 3.2 EQUIPMENT CALIBRATION

Calibrate equipment in accordance with AWS D1.1/D1.1M, Clause 6, Part F.

### 3.3 INSPECTION PROCEDURE

Inspect all welds in accordance with JASS 6 and JIS Z 3060.

### 3.4 ACCEPTANCE - REJECTION CRITERIA

In accordance with AWS D1.1/D1.1M, Table [6.2] [or 6.3].

#### 3.4.1 Inspection Test Reports

Submit test reports containing the following information:

##### 3.4.1.1 Identification and Location of Inspection

Connection identification and location of the inspected item, the person performing the inspection, and the date of inspection.

##### 3.4.1.2 Detail of Inspections

Details of methods, types of waves used, search units, frequencies, inspection equipment identification, and calibration data with enough information to permit duplication of the inspection at a later date.

##### 3.4.1.3 Identification of Unacceptable Areas

Locations, dimensions, types, and area of unacceptable defects and discontinuities giving reflections over 50 percent of the reject/repair line. Note on a sketch or marked-up drawing.

##### 3.4.1.4 Record of Repair Areas

A record of repaired areas must be furnished as well as test results for the repaired areas.

#### 3.4.2 Inspection of Repairs

All repairs undergo the same inspection procedure that originally revealed the discontinuities. Before acceptance, the welds must meet the standards required for the original weld.

-- End of Section --