UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated January 2021
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01/08

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USACE / NAVFAC / AFCEC / NASA	**UFGS-41 36 30.00 10 (January 2008)**

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UNIFIED FACILITIES GUIDE SPECIFICATIONS

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SECTION 41 36 30.00 10

ULTRASONIC INSPECTION OF PLATES
01/08

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NOTE: This guide specification covers the requirements for ultrasonic inspection of rolled steel plates.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

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PART 1 GENERAL

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NOTE: This guide specification covers the ultrasonic inspection of rolled plates both in air and by immersion techniques for laminar types of flaws, for lack of bonding between plate and cladding, and for lack of fusion between the welded overlay and the base metal. Where ultrasonic inspection of weldments is to be required, use Section 05 05 23.16.13 10 ULTRASONIC INSPECTION OF WELDMENTS. If the work will involve both ultrasonic inspection of plates and of weldments, this section and Section 05 05 23.16.13 10 ULTRASONIC INSPECTION OF WELDMENTS may be used as separate sections of the contract specifications, or may be combined into a single section to be titled ULTRASONIC INSPECTION. If combined, repetitions will be deleted, and the

entire specification will be edited for appropriate paragraphs and definitions, reference specimens, acceptance/rejection standards, and other associated data.

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1.1 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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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 SOCIETY FOR NONDESTRUCTIVE TESTING (ASNT)

ASNT SNT-TC-1A	(2020) Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing
ASNT SNT-TC-1A Q&A Bk C	(2011; Text Correction 2011) Supplement to Recommended Practice No. SNT-TC-1A (Q&A Book): Ultrasonic Testing Method

AMERICAN WELDING SOCIETY (AWS)

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

ASTM INTERNATIONAL (ASTM)

ASTM E165/E165M	(2018) Standard Practice for Liquid Penetrant Examination for General Industry
ASTM E709	(2015) Standard Guide for Magnetic Particle Examination

1.2 DEFINITIONS

1.2.1 A Scan

Method of data presentation on a cathode ray tube 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 0.001 dB/mm 0.25 dB/inch 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 Attenuation-Correction Controls

Circuitry to provide a continuous increased amplification with respect to time. This circuitry compensates for the reduction in sensitivity with depth as a result of sound beam divergence and its attenuation in material.

1.2.6 Back Reflection or End Reflection

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

1.2.7 Calibrated Gain Control (Attenuator)

Circuitry with which gain can be increased or reduced finite amounts by switching electrical signal attenuation into the circuit.

1.2.8 Calibration

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

1.2.9 Cathode Ray Tube (CRT)

Electron tube in which a controlled beam of electrons from the cathode is used to produce an image on a fluorescent screen at the end of the tube.

1.2.10 Couplant

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

vibrations between the search unit and the material being inspected.

1.2.11 Damping Control

Control that varies the duration of transducer ringing.

1.2.12 Decibel (dB)

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

1.2.13 Delay Control

Means of delaying the pattern obtained on the cathode ray tube.

1.2.14 Discontinuity

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

1.2.15 Distance-Amplitude Correction Curve

Curve showing the relationship between signal amplitude and equal-sized reflecting surfaces at various distances from the transducer. Reference standards are used to obtain such curves.

1.2.16 Dynamic Range

Ratio of maximum to minimum size of reflective areas that can be adequately distinguished on the cathode ray tube at a constant gain setting.

1.2.17 Effective Depth of Penetration

Maximum depth at which the sensitivity is satisfactory for the quality of test desired.

1.2.18 Examination

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

1.2.19 Gain Control

Circuitry designed into the ultrasonic system to vary reflection amplitude. This control is usually calibrated in decibels. It is also called the sensitivity control.

1.2.20 Gross

Background displacement of the trace on the cathode ray tube from the established baseline due to the gain setting, the characteristics of the test equipment, or the material under examination.

1.2.21 Hertz

One complete set of recurrent values of a periodic quality 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. A hertz is a unit of frequency equal to one cycle per second.

1.2.22 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.

1.2.23 Indication

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

1.2.24 Initial Pulse Indication

Usually called the "initial pulse". A signal on the CRT screen marking the instant at which a voltage impulse is applied to the transmitting crystal. Its rising edge is frequently invisible due to the time lag in the probe shoe and the consequent necessity to ensure coincidence between the time base zero and the instant at which the transmitter pulse actually enters the material under test.

1.2.25 Linearity

Property of an instrument revealed by a linear change in reflected signal or displacement. The vertical linearity is determined by plotting by 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.

1.2.26 Longitudinal or Compressional Waves

Simple compression refraction 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.

1.2.27 Longitudinal Wave Inspection

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

1.2.28 Mid-Screen Reflection

Reflection whose amplitude is equal to one-half the usable screen height on the CRT.

1.2.29 Megahertz (MHz)

One million hertz per second frequency.

1.2.30 NDT Level I

An NDT Level I individual should be qualified to properly perform specific calibrations, specific NDT, and specific evaluations for acceptance or rejection determinations according to written instructions, and to record results.

1.2.31 NDT Level II

An NDT Level II individual should be qualified to set up and calibrate equipment and to interpret and evaluate results with respect to applicable codes, standards, and specifications.

1.2.32 NDT Level III

An NDT Level III individual should be capable of establishing techniques and procedures; interpreting codes, standards, specifications, and procedures; and designating the particular NDT methods, techniques, and procedures to be used.

1.2.33 Node

Distance a shear wave travels in a straight line from the inspection surface before being reflected by the opposite surface.

1.2.34 Pulse Repetition Rate

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

1.2.35 Range Control

Means of expanding the pattern obtained on the CRT so any portion of the total distance being tested can be presented.

1.2.36 Reference Reflector

Standard reflector 1.52 mm 0.060 inch diameter reference hole in the IIW reference block. Other approved blocks may have a different diameter reflector.

1.2.37 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.

1.2.38 Refracted Waves

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

1.2.39 Rejectable Discontinuity (Defect)

Reflector large enough to produce a signal (decibel rating) that exceeds the reject/repair line.

1.2.40 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 distance from the far or back surface when the sound beam is normal to that back surface.

1.2.41 Ringing

Excitation of the transducer crystal due to a short pulse of high-voltage electricity.

1.2.42 Scanning

Process of moving the search unit or units along a test surface to obtain complete inspection of the entire volume of a material being inspected.

1.2.43 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 technique.

1.2.44 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".

1.2.45 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.

1.2.46 Shear Wave Inspection

Inspection technique using shear waves in a material. The search unit is placed at an angle to the contact surface of the material so the resultant refracted sound is a shear wave at an angle to the normal.

1.2.47 Standard Reference Level

Mid-screen height reflection when beaming at the 1.52 mm 0.060 inch hole in the primary reference block or the reference hole in the secondary standard.

1.2.48 Surface Waves

Waves that propagate along the surface of the material and penetrate it to only about 1/2 wavelength. Also known as Rayleigh waves.

1.2.49 Test Frequency

Operating frequency in hertz per second of the search unit during period of activation. Frequency is usually expressed in megacycles per second or megahertz. The latter term has been adopted for international use and is preferred.

1.2.50 Video Form

Type of signal presentation on a CRT in which only the upper or position half of the signal appears.

1.3 SYSTEM DESCRIPTION

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NOTE: The designer will indicate the extent of inspection required, where the inspection shall be made, and the number of plates to be inspected. The number will depend on the service to which the plates will be subjected. For example, all plates intended for pressure vessels and dynamically loaded structures such as rail and highway bridges, cranes, and missile service towers shall be inspected. In the case of plates for statically loaded structures such as buildings and storage tanks, inspection shall be on the basis of heats in which the sample size shall be in accordance with the governing specifications or standards for tensile tests. However, the plates intended for ultrasonic inspection shall not be the same as those from which the tensile specimens were taken. For economy, plates should be inspected at the mill following final processing and before shipment. However, in some instances, this may not be expedient. Where critical, the designer shall specify in detail the occasion for inspection in the construction process.

****

This section includes procedures, methods, standards, and descriptions of equipment which shall be used for [mill] [shop] [field] inspection of rolled plate, including clad materials which are 13 mm 1/2 inch or thicker, through which interpretable ultrasonic penetration is possible. Inspection of plate shall be [individually.] [by lots. The sample size shall be two plates per lot. A lot is defined as being all plates in a 50 mm 2 inch thickness interval rolled from the same heat. Include in the thickness determination any overlay, pressure cladding, or weld deposit.] Perform ultrasonic inspection to detect the following defects:

a. [Internal laminar discontinuities.]

b. [Lack of bond between roll or explosive bonded sheet.]

c. [Lack of fusion between welded overlays and base plate.]

1.4 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy, Air Force, and NASA projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

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

SD-03 Product Data

Procedures and Methods

Personnel Qualification and Certification

Equipment Qualification Requirements

SD-06 Test Reports

Reports and Results

1.5 QUALITY ASSURANCE

1.5.1 Personnel Qualification and Certification

Personnel shall be qualified to perform ultrasonic inspection, as defined in ASNT SNT-TC-1A. Personnel shall be certified under ASNT SNT-TC-1A and ASNT SNT-TC-1A Q&A Bk C within a period of 1 year before the date of this contract. 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 shall be able to pass judgement on the acceptability of the item in accordance with paragraph ACCEPTANCE/REJECTION LIMITS.

1.5.2 Examinations

If the Contracting Officer doubts an individual's ability as an operator, inspector, or supervisor, the individual shall be recertified in accordance with ASNT SNT-TC-1A. The Contracting Officer may participate in administering the examination and in evaluating the results.

1.6 REFERENCE STANDARDS

Reference standards shall be used 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 QUALIFICATION REQUIREMENTS. The standards shall comprise a standard reference block and working standards as described next.

1.6.1 Standard Reference Block

Provide the standard reference block or primary standard consisting of the International Institute of Welding (IIW) reference block in AWS D1.1/D1.1M, Section: Inspection, subsection, Reference Standards. The standard reference block shall also be used 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.

1.6.2 Working Standards

Recognized working standards detailed with the IIW block in AWS D1.1/D1.1M, such as the Sensitivity Calibration Block, may be used. Details of their use must be included in the procedure description submitted for approval. These blocks shall be of the same acoustical material as the plates to be inspected, shall be suited for the applicable tests specified in paragraph EQUIPMENT QUALIFICATION REQUIREMENTS, and shall be used as follows except where the IIW block is specifically required:

a. To assure adequate penetration of the base material.

b. To provide a secondary field standard.

c. To calibrate the equipment and to establish the standard reference level.

1.6.3 Resolution Test Block

Furnish a resolution test block in accordance with the details shown in

AWS D1.1/D1.1M, Section: Inspection, subsection Reference Standards.

1.7 EQUIPMENT QUALIFICATION REQUIREMENTS

Evaluate the ultrasonic instrument and accessories on their arrival at the jobsite just before the start of the inspection, using the Contractor's furnished primary standard; they shall meet or exceed the requirements below. Equipment that does not meet these requirements shall not be used.

Submit the procedure specifications, the procedure qualification test records and the personnel qualification test records.

1.7.1 Requalification

The equipment shall be requalified after normal use at intervals not to exceed 40 hours. In addition, equipment shall be requalified immediately after maintenance or repair or when the Contracting Officer considers its operation questionable.

1.7.2 Longitudinal Wave System

1.7.2.1 Horizontal Linearity

The first three multiple reflections obtained through the thickness of the primary or secondary standard shall be equally spaced within plus or minus 5 percent when spread over 90 percent of the sweep length.

1.7.2.2 Vertical Amplitude Linearity

Two adjacent reflections of different amplitudes obtained through the thickness of the primary or secondary standard shall vary in the same proportion as the amplitude of the first reflection is increased in discrete 2-dB increments between 20 and 80 percent of full screen height. For each gain setting, the amplitude of each reflection shall vary by the same factor within plus or minus 5 percent.

1.7.2.3 Near-Surface Resolution

Excessive ringing that appears on the cathode ray tube (CRT) just to the right of the sound entry point shall not exceed a 13 mm 1/2 inch equivalent distance in steel with the search unit placed on the 100 mm 4 inch edge of the IIW block and positioned for maximum amplitude reflection from the 1.52 mm 0.060 inch hole. The reference reflector shall be set to mid-screen and the gain shall be increased 20 dB. In either case, excessive ringing shall not appear on the CRT to the right of the sound entry point in excess of a 13 mm 1/2 inch equivalent distance in steel. The reference hole located at least 13 mm 1/2 inch from one edge of the AWS D1.1/D1.1M, Type SC secondary standards shall be used similarly. Acceptability shall be on the same basis as in the primary standard.

1.7.2.4 Far-Surface Resolution

The equipment shall delineate the three resolution holes in the resolution block appropriate for the angle of the transducer to be used in the inspection.

1.7.2.5 Signal-to-Noise Ratio

With the search unit located as in the near-surface resolution tests, the

gain shall be set to obtain an 80-percent full screen height first reflection from the respective reference reflector. The reference reflection-to-noise shall not be less than 10 to 1.

1.7.2.6 Penetration

At least three multiple back reflections through plates up to 75 mm 3 inches thick and at least one for plates greater than 75 mm 3 inches thick shall be obtained. In either case, the initial or back reflection only shall fall within mid-screen range with a gain input no greater than 50 percent of the instrument capacity.

1.7.3 Immersion Testing

For immersion techniques, the back reflection from the interface between the couplant and the plate surface is called the "first interface signal". All measurements are to be referenced to this signal. The equipment shall meet all requirements of paragraph EQUIPMENT SENSITIVITY CALIBRATION.

1.8 EQUIPMENT SENSITIVITY CALIBRATION

Sensitivity calibration shall be done immediately after a change of operators and at least every 30 minutes thereafter as testing proceeds. Recalibration shall also be required after any power interruption, including a change of source, when the equipment is suspected of being in error, or after relocation on the jobsite. The 30-minute and relocation calibrations may coincide. Before calibration is attempted, the instrument shall be allowed to warm up.

1.8.1 Calibration of Longitudinal Wave System

The instrument range and delay controls shall be adjusted to display signals from the far surface of the plate to be inspected. The gain shall be adjusted to produce a first back reflection 50 percent of full-scale. The reject/repair line shall be established at 40 percent of full-scale or 2 dB below mid-screen height. The relationship between the 50-percent reflection and the first back reflection from the 1.52 mm 0.060 inch reference hole in the primary standard shall be determined in the following way: without further adjustment of the instrument gain after the initial sensitivity setting, the transducer shall be coupled to the primary standard and positioned for a maximum first back reflection from the 1.52 mm 0.060 inch reference hole. The instrument gain shall be adjusted to bring the maximum reflection to mid-screen height and this instrument gain setting shall be recorded. A similar relationship, correlated with the respective plate identifications, shall also be reported for each subsequent plate inspected. Adjustment for loss of signal due to distance shall be compensated for as specified below. However, for plates less than 25 mm 1 inch thick, no adjustment for loss of signal is required.

1.8.2 Calibration of Secondary Standard

After adjusting the first reflection from the reference hole in the secondary standard to a 50-percent full-scale response for a shear or longitudinal wave inspection, a maximized reflection from the 1.52 mm 0.060 inch reference hole in the primary standard shall be obtained without changing the gain setting. This gain setting shall be readjusted to obtain a 50-percent full-scale reflection. The readjusted setting

shall be recorded to provide a basis for recalibration when the secondary standard is unavailable.

1.8.3 Equipment With a Calibrated Gain Control

When a calibrated gain control attenuator is used, the transducer shall be positioned for maximum reflection from the reference hole in the secondary standard representing approximately 1/2 the longest inspection distance. This reflection shall be adjusted to mid-scale by varying the gain control accordingly. The difference in decibels between this amplitude and the signals obtained from the first, second, and longest distance reflections obtainable on the secondary standard shall be measured. The differences shall be recorded and plotted on a curve to determine the necessary correction to the amplitude at the various inspection distances. A level 80 percent of the primary level, obtained from the corrected signal heights, is equal to the reject/repair line.

1.8.4 Equipment With Electronic Distance Compensation Circuitry

If the distance in amplitude between the first reflection and the reflection obtained from the maximum inspection distance is 1 dB or less, the instrument may be used as is. If not, the procedure used for equipment with a calibrated decibel control shall be used to determine the necessary correction for the reflections obtained at the various inspection distances.

1.8.5 Longitudinal Wave Distance-Amplitude Corrective Curve

A longitudinal wave distance-amplitude correction curve shall be constructed and drawn on the face of the CRT when longitudinal waves are to be used in the inspection and when material thickness exceeds 50 mm 2 inches if the test equipment design permits. The reference hole in the secondary standard shall be used. The instrument sensitivity shall be adjusted to 50 percent full-scale of the maximized response from the reference hole at 1/2 maximum inspection distance. The reject/repair line shall be constructed at 80 percent of the established distance-amplitude curve. The reflection amplitudes to define this curve shall be taken from the faces of the secondary sensitivity standard which are 25 mm 1 inch, 50 mm 2 inches, 1/2 maximum inspection distance, and the longest distance obtainable from the secondary standard, respectively, from the reference hole. When a correction curve cannot be drawn on the face of the CRT, an approved distance-amplitude correction method shall be applied.

1.8.6 Longitudinal Wave Inspection Using Immersion Techniques

The reference hole in a secondary standard shall be used for each different inspection distance. Reject/repair limits shall be established by immersing both the search unit and secondary standard in the liquid bath in which the inspection is to be conducted. The following procedure shall be used:

a. The longitudinal waves from the search unit shall be directed toward the face of the secondary standard closest to the reference hole.

b. The search unit shall be positioned for maximum response. The amplitude of reflection shall be adjusted to 50 percent full-scale. The top of that indication on the CRT shall be marked with a wax pencil or by other means. This establishes the standard reference

level. A point at 80 percent of the standard reference level shall be calculated and marked. This locates the reject/repair point. The above procedure shall be repeated for each different surface-to-hole distance to establish reject/repair lines.

c. With the gain at the same setting and primary standard and search unit in the bath, a maximized reflection from the 1.52 mm 0.060 inch reference hole in the primary standard shall be obtained. This gain setting shall be readjusted to obtain a 50-percent full-scale reflection. The readjusted setting shall be recorded to provide a basis for recalibration when the secondary standard is unavailable.

1.8.7 Angle Wave System

The sensitivity level shall be a minimum of a mid-screen height, 50-percent back reflection, with the transducer placed at the first node position from a plate edge. No other calibration tests are required unless repair of discontinuity excavation is accomplished by welding. In that case, when inspection of the weld repair is required, qualification and calibration of the shear wave equipment shall be accomplished in accordance with Section 05 05 23.16.13 10 ULTRASONIC INSPECTION OF WELDMENTS.

PART 2 PRODUCTS

2.1 ULTRASONIC EQUIPMENT

The ultrasonic test instrument shall conform to the requirements listed in AWS D1.1/D1.1M, Section: Inspection, subsection, Ultrasonic Equipment, except any requirement relating to weld inspection and the following additional requirements:

2.1.1 Pulses

Provide an ultrasonic test instrument able to generate, receive, and present pulses in any frequency in the 1- to 10-megahertz (MHz) range.

2.1.2 Horizontal Linearity Test

Test the horizontal linearity of the ultrasonic instrument in accordance with the requirements for horizontal linearity of paragraph EQUIPMENT QUALIFICATION REQUIREMENTS, in addition to the AWS D1.1/D1.1M requirement.

2.1.3 Resolution Tests

In addition to the resolution test specified in AWS D1.1/D1.1M for ultrasonic equipment, both near- and far-surface resolution tests shall be conducted in accordance with the procedures specified for those characteristics in paragraph EQUIPMENT QUALIFICATION REQUIREMENTS.

2.2 PROCEDURES AND METHODS

Use the pulse echo contact method with an A scan presentation for the ultrasonic inspection of plate except when immersion techniques may be approved for use in some applications. Submit for approval the procedures to be used for personnel and equipment qualification, equipment calibration, and inspection at least 30 days before their intended use. Approval will in no way affect the Contractor's obligation to employ qualified personnel, equipment, and procedures, and to perform the

inspection as specified. The procedure description shall include the following:

a. Type of couplant.

b. Search unit characteristics including shape, nominal frequency, diameter, type, and transducer angle if other than straight.

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.

2.3 TEST FREQUENCY

The test frequency for ferrous materials shall be as specified in AWS D1.1/D1.1M, Section: Inspection, subsection, Ultrasonic Equipment. For other materials that are difficult to penetrate, any frequency within the operating range of the equipment may be used. The effective depth of penetration and sound beam divergency shall be demonstrated to the Contracting Officer.

2.4 WAVE TYPES

The types of waves and conditions under which they shall be used shall be as follows:

2.4.1 Longitudinal Waves

Longitudinal waves shall be used to locate, identify, and evaluate defects in the various plate materials to be inspected.

2.4.2 Shear Waves

Shear waves may be used as a supplementary means of inspection to locate questionable areas.

2.5 CHANGES IN PROCEDURE

Should application of an approved procedure not provide for good resolution or adequate ultrasonic penetration as specified in paragraph EQUIPMENT QUALIFICATION REQUIREMENTS, changes in procedure or equipment such as frequency, pulse repetition rate, angle of search unit, couplant, or oscilloscope shall be made and approved. Adequacy of the new procedure shall be demonstrated to the Contracting Officer. During these tests, if any of the test system's characteristics fall below the levels listed in paragraph EQUIPMENT QUALIFICATION REQUIREMENTS, the Government reserves the right to require a change in procedure or equipment.

PART 3 EXECUTION

3.1 PREPARATION OF MATERIALS FOR INSPECTION

The inspection surface shall be clean and free of loose scale, dirt, rust, grease, oil (other than couplant), and paint. Any roughness on the inspection surface that could interfere with transmission of the

ultrasound into the material shall be ground smooth enough to obtain a back or end reflection in excess of 40 percent full-scale. Plates shall be inspected after final heat treatment or processing. Plate identification removed by grinding or other means shall be restored after inspection.

3.2 INSPECTION PROCEDURE

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NOTE: The designer shall specify limits closer than those cited if the application is judged critical.

Inapplicable words, sentences, and paragraphs shall be deleted when the item mentioned is not to be furnished under this contract; for example, if clad plate is not furnished, all reference to clad plate shall be deleted.

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Inspection for [laminar types of flaws and] lack of fusion between welded overlay [or explosion bonded sheet] [and the base metal] shall be made as detailed below with the search unit coupled to the base plate. The correct frequency as defined in paragraph TEST FREQUENCY shall be used. Final evaluation for acceptance or rejection shall be performed with the equipment properly calibrated and the gain control set at the reference level. The reject/repair line shall be used to evaluate the quality of each item inspected. If a periodic calibration check shows that the equipment is not operating properly or that the sensitivity of the system has decreased more than 20 percent or 2 dB from the established sensitivity level, all items that have been inspected since the previous calibration shall be reexamined. When adequate penetration, as specified in paragraph EQUIPMENT QUALIFICATION REQUIREMENTS, cannot be obtained by the proposed longitudinal wave method, modify the procedure in accordance with paragraph CHANGES IN PROCEDURE.

3.2.1 Couplants

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NOTE: The designer may limit the choice of couplants if some couplants are considered injurious to the item to be inspected.

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The choice of couplant, such as oil or water, is optional, except as follows:

a. The couplant shall be the same as that used for equipment qualification and calibration.

b. Couplants that may cause corrosion of the reference standards or the material being tested shall not be used.

c. Oil shall not be used for plate to be installed in systems that will handle liquid oxygen.

d. Couplants shall have the proper viscosity to overcome surface roughness or irregularities.

3.2.2 Detection of Laminar Types of Flaws

a. The plates shall be marked off in grid lines with a maximum spacing of 12 inches between lines, tested along each grid line and also along a path within one thickness (T) of the plate from each plate edge.

b. The back or end reflection from the far surface of the plate shall be maintained in excess of 40-percent of full-scale screen height during the entire inspection to assure adequate ultrasonic penetration.

c. When a complete loss of back or end reflection occurs along any grid line, the entire area of the square adjacent to that point shall be inspected. Complete testing of all additional adjacent squares shall be continued until the extent of the defective area is defined.

3.2.3 Detection of Lack of Bonding: Base Plate and Cladding

a. The clad area shall be inspected for any lack of bonding between the cladding and the base metal. The clad area shall be marked off in grid lines with a maximum spacing of 150 mm 6 inches between lines, tested along each grid line and also along a path within T of each edge.

b. The inspection shall be made from the base metal side, provided the interface between the base plate and overlay can be resolved.

3.2.4 Detection of Lack of Fusion: Welded Overlay and Base Plate

a. The fusion-welded area shall be inspected for any lack of fusion between the overlay and the base plate. The fusion-welded area shall be marked off in grid lines with a maximum spacing of 150 mm 6 inches between lines, tested along each grid line and also along a path within T of each edge.

b. The inspection shall be made from the base metal side, provided the interface between the base plate and overlay can be resolved.

3.2.5 Immersion Techniques for Longitudinal Wave Inspection

This procedure may be used at the Contractor's option unless otherwise specified. Plates shall be inspected for laminar type of flaws, lack of bonding between base plate and cladding, or lack of fusion between welded overlay and the base metal, as appropriate. In addition, provision shall be made for immersing the plate and mounting the transducer in a fixture so that its motion along the required grid patterns can be controlled accurately.

3.3 ACCEPTANCE/REJECTION LIMITS

Discontinuities shall be evaluated only when the ultrasonic equipment is properly calibrated. If discontinuities are detected, the sound beam shall be directed to maximize the signal amplitude. To determine the length of a discontinuity, the search unit shall be moved parallel to the discontinuity axis in both directions from the position of maximum signal amplitude. One-half the amplitude (or a 6-dB increase in sensitivity) from a point at which the discontinuity signal drops rapidly to the baseline shall be defined as the extremity of the discontinuity. For discontinuities whose signal amplitudes exceed full screen height,

50-percent full-screen shall be considered half peak amplitude of the signal. At this point, the scanning surface shall be marked at the position indicated by the center of the transducer. This procedure shall be repeated to determine the other extremity. The length of the discontinuity shall be defined as the distance between these two marks. The maximum signal amplitude, length, depth, and position within the inspection zone shall be determined and reported for discontinuities yielding a signal amplitude equal to or exceeding the reject/repair line. The minimum recordable length of discontinuity shall be 13 mm 1/2 inch.

3.3.1 Investigation of Questionable Indications

Any indications considered doubtful shall be brought to the attention of the Contracting Officer, and the plate shall be repaired or investigated further as directed. Indications detected within 10 mm 3/8 inch or less of accessible surfaces shall be investigated further by liquid penetrant as provided in ASTM E165/E165M, or by magnetic particle methods in accordance with ASTM E709, as applicable, to determine if they penetrate the surface. Failure to locate the flaws by one of these methods shall require further investigation by the other. For nonmagnetic materials, only dye penetrant inspection is required. Other questionable defects shall be further investigated by modifications of the inspection procedure in accordance with paragraph CHANGES IN PROCEDURE.

3.3.2 Inspection of Repairs

Repairs shall be reexamined by the same procedure that originally detected the faults, and shall meet the standards of acceptance for the original plate. More than two repairs to the same area are to be accepted at the discretion of the Contracting Officer.

3.3.3 Acceptance Standards

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NOTE: The extent and diameters of defective areas depend on the class of service intended for the plates undergoing inspection. The designer will indicate the applicable class or classes and the intended service in the blank space provided for this purpose. For example: "All plate materials intended for dynamically loaded structures shall conform to Class I requirements; those designed for foundations shall conform to Class III requirements". Where only one class of service is required, inapplicable matter in parentheses will be deleted.

The tolerable extent of lack of bond depends on the service requirement of the plates and the severity of forming operations which might increase the size of the discontinuities judged acceptable. Reinspection of areas for lack of bond or fusion shall be specified if the designer believes the original "safe" areas will extend after cold forming.

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Plates will be unacceptable if they contain any of the defective areas detailed below:

a. Laminar types of flaws shall be evaluated on the basis of their proximity to the plate surfaces. For evaluation, the zonal locations defined below shall be applied in terms of base plate thickness, T. The T/4 criteria apply when the flaw is situated within T/4 distance of their nonoverlaid or base plate surfaces. The T/2 criteria apply to flaws located in the cross sectional area between T/4 layers of either overlaid or base plate surface. The T/4 criteria shall apply if the flaw extends from one zone to the other. Any single or two or more defects resulting in a reflection that exceeds the reject/repair line simultaneously with a continuous loss of back reflection from the far surface shall be cause for rejection, provided the extent of the single or multiple defects cannot be contained within a circle whose diameter is subject to the limits listed in TABLE II. Plate materials intended for [_____] shall conform to class [_____] requirements whereas those intended for [_____] shall conform to class [_____]. [Other plate materials shall conform to class [_____] requirements.]

b. Lack of bond criteria shall apply to areas at which the cladding is overlaid on the base plate by a pressure or forging process. Lack of bond type flaws include:

(1) Any area that results in an interface back reflection exceeding the reject/repair line and that cannot be contained within a circle of 150 mm 6 inch diameter.

(2) Two or more smaller areas, each of which results in interface back reflection exceeding the reject/repair line, and which cannot be contained within a circle of 150 mm 6 inch diameter unless separated by a distance equal to the maximum dimension of the larger detective area.

(3) Any area that results in an interface back reflection exceeding the reject/repair line and that is closer than 50 mm 2 inches or less to any point at which penetrations are to be made through the cladded thicknesses.

c. Lack of fusion criteria shall apply to areas at which cladding is overlaid on the base plate by a fusion welding process. Lack of fusion type flaws include:

(1) Any area that results in an interface back reflection exceeding the reject/repair line and that cannot be contained within a circle of 150 mm 6 inch diameter.

(2) Two or more smaller areas, each of which results in an interface back reflection exceeding the reject/repair line, and which cannot be contained within a circle of 150 mm 6 inch diameter unless separated by a dimension equal to, or greater than the larger defect.

(3) Any in-line inclusions in the overlay, 25 mm 1 inch long or equal to 1/2 the plate thickness, whichever is greater.

(4) Any area that results in an interface back reflection exceeding the reject/repair line that is closer than 50 mm 2 inches or less to any point at which penetrations are to be made through the cladded thickness.

3.4 REPAIRS AND REPLACEMENT

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NOTE: The designer will indicate or specify, directly or by reference to a suitable publication, the limiting dimensions for repairable defects. Where no applicable specifications exist, repairs will be limited to those areas at which their depth extends within 3/8 the plate thickness of the surface.

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Plates containing defects in excess of the limit specified shall be replaced on a one-for-one basis or, at the Contractor's option, may be repaired if such defects are within the limits shown in TABLE I. [When plates are inspected on a lot basis, each plate in the lot shall be individually inspected if more than one plate in the representative sample is found defective.] Repairs shall be reexamined by the same procedure originally used to detect the faults, and the repairs must conform to the standards listed in paragraph ACCEPTANCE/REJECTION LIMITS.

TABLE I. PERCENTAGE OF PLATE AREA ALLOWED FOR REPAIRS

Plate Class	Area Allowed for Repairs
I	1.0 pct
II	1.5 pct
III	2.0 pct

3.5 REPORTS AND RESULTS

Reports containing the following information shall be submitted to the Contracting Officer:

a. Identification of each production plate by heat number and plate number, plate thickness, and the initial and final decibel settings needed for correlation of the plate back reflection with the standard reference block reflection as specified in paragraph EQUIPMENT SENSITIVITY CALIBRATION. Heat number and plate number shall be permanently recorded on each production plate.

b. Place of plate inspection.

c. Identification and description of the standard reference block.

d. Details of methods, types of waves used, search unit, frequencies, inspection equipment identification, and calibration data with enough detail to permit duplication of the inspection later.

e. Locations, dimensions, area (if any) of unacceptable defects and their repairs. These may be noted on a sketch or marked-up drawing.

f. A record of repaired areas as well as the results of the repaired area reinspection.

TABLE II. SINGLE AND MULTIPLE AREA REJECTION LIMITS FOR LAMINAR TYPE FLAWS				
Class	Criterion	No. of Defects	Diameter of Enclosing Circle	Minimum Spacing Between Defects
I	T/4	Single	75 mm3 in. or 1/2 plate thickness, whichever is greater	
		Multiple	Same as single	Equal to or greater than the maximum dimension of the larger defect
	T/2	Single	90 mm3.5 in. or 5/8 plate thickness, whichever is greater	
		Multiple	Same as single	Equal to or greater than 7/8 maximum dimension of the larger defect
II	T/4	Single	90 mm3.5 in. or 5/8 plate thickness, whichever is greater	
		Multiple	Same as single	Equal to or greater than 3/4 maximum dimension of the larger defect
	T/2	Single	95 mm3.75 in. or 3/4 plate thickness, whichever is greater	
		Multiple	Same as single	Equal to or greater than 5/8 maximum dimension of the larger defect

TABLE II. SINGLE AND MULTIPLE AREA REJECTION LIMITS FOR LAMINAR TYPE FLAWS				
Class	Criterion	No. of Defects	Diameter of Enclosing Circle	Minimum Spacing Between Defects
III	T/4	Single	100 mm4 in. or 7/8 plate thickness, whichever is greater	
		Multiple	Same as single	Equal to or greater than 1/2 maximum dimension of the larger defect
	T/2	Single	110 mm4.25 in. or plate thickness, whichever is greater	
		Multiple	Same as single	Equal to or greater than 3/8 maximum dimension of the larger defect

-- End of Section --