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# Standard Guide for Detection and Evaluation of Discontinuities by Contact Pulse-Echo Straight-Beam Ultrasonic Methods[1]

This standard is issued under the fixed designation E 1901; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This guide covers procedures for the contact ultrasonic examination of bulk materials or parts by transmitting pulsed ultrasonic waves into the material and observing the indications of reflected waves. This guide covers only examinations in which one search unit is used as both transmitter and receiver (pulse-echo). This guide includes general requirements and procedures that may be used for detecting discontinuities, locating depth and distance from a point of reference and for making a relative or approximate evaluation of the size of discontinuities as compared to a reference standard.

1.2 This guide complements Practice E 114 by providing more detailed procedures for the selection and calibration of the inspection system and for evaluation of the indications obtained.

1.3 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only.

1.4 *This guide does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this guide to establish the appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*

E 114 Practice for Ultrasonic Pulse-Echo Straight-Beam Examination by the Contact Method[2]

E 127 Practice for Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks[2]

E 317 Practice for Evaluating Performance Characteristics of Ultrasonic Pulse-Echo Testing Systems Without the Use of Electronic Measurement Systems[2]

E 428 Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Inspection[2]

E 543 Practice for Evaluating Agencies that Perform Nondestructive Testing[2]

E 1158 Guide for Material Selection and Fabrication of Reference Blocks for the Pulsed Longitudinal Wave Ultrasonic Examinations of Metal and Metal Alloy Production Materials[2]

E 1316 Terminology for Nondestructive Examinations[2]

2.2 *ASNT Standard:*

SNT-TC-1A Recommended Practice for Personnel Qualification and Certification in Nondestructive Testing Personnel[3]

2.3 *ANSI/ASNT Standard:*

CP-189 ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel [3]

2.4 *Military Standard:*

MIL-STD-410 Nondestructive Testing Personnel Qualification and Certification[4]

## 3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide, see Terminology E 1316.

## 4. Basis for Application

4.1 *Contractual Agreement*—The using parties shall agree on the applicable procedural requirements, as listed herein, prior to the examination of any material.

4.1.1 Materials, sizes, and shapes examined,

4.1.2 Stage of manufacture when examined (time of test),

4.1.3 Surface finish requirements,

4.1.4 Minimum equipment requirements, as in Table 1 herein,

4.1.5 Search unit size, frequency and type,

4.1.6 Couplant,

4.1.7 Automated turning, fixturing or scanning, or both, as applicable,

4.1.8 Type of reference block standards including surface curvature,

4.1.9 Standardization details, including attenuation compensation and DAC techniques,

4.1.10 The surfaces to be examined and the scanning path,

[1] This guide is under the jurisdiction of ASTM Committee E-07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.06 on Ultrasonic Method.

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[2] *Annual Book of ASTM Standards*, Vol 03.03.

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th Floor, New York, NY 10036.

[4] Available from Standardization Documents Order Deck, Bldg. 4 Section D, 700 Robbins Ave., Philadelphia, PA 19111–5094, Attn: NPODS.

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TABLE 1 Minimum Equipment Requirements (Longitudinal Wave)

| Instrument Characteristics | Ultrasonic Test Frequency MHZ (Record) |
|---|---|
| Vertical limit, in. (mm) or percent of full screen height | |
| Upper vertical linearity limit in. (mm) or percent of full screen height | |
| Lower vertical linearity limit in. (mm) or percent of full screen height | |
| Ultrasonic sensitivity, hole size, 64 ths, distance, in (mm) | |
| Entry surface resolution, in. (mm) | |
| Back surface resolution in. (mm) | |
| Horizontal limit, in. (mm) or percent of full screen width | |
| Horizontal linearity range, in. (mm) or percent of full screen width | |

4.1.11 Acceptance standards,

4.1.12 Personnel certification level, and

4.1.13 Instrument characteristics.

4.2 *Written Procedure*—Ultrasonic examinations performed in accordance with this guide shall be detailed in a written procedure. Documentation of procedure qualification shall be maintained by the preparer. Procedures shall be sufficiently detailed so that other qualified examiners may duplicate the examination and obtain equivalent results.

4.3 *Personnel Qualifications*—Personnel performing ultrasonic examinations in accordance with this guide shall be qualified in accordance with a nationally recognized NDT personnel qualification practice or standard; such as SNT-TC-1A, ANSI/ASNT CP-189, MIL-STD-410, or a similar document. The practice or standard used and its applicable revision shall be specified in the contractual agreement between the using parties.

4.4 If specified in the contractual agreement, NDT agencies shall be qualified and evaluated as described in Practice E 543.

## 5. Summary of Guide

5.1 This guide describes a means for obtaining an evaluation of discontinuities in materials by contact examination using longitudinal waves. Equipment, reference standards, examination and evaluation procedures, and documentation of results are described in detail.

## 6. Significance and Use

6.1 This guide provides procedures for the application of contact straight-beam examination for the detection and quantitative evaluation of discontinuities in materials.

6.2 Although not all requirements of this guide can be applied universally to all inspections, situations, and materials, it does provide basis for establishing contractual criteria between the users, and may be used as a general guide for preparing detailed specifications for a particular application.

6.3 This guide is directed towards the evaluation of discontinuities detectable with the beam normal to the entry surface. If discontinuities or other orientations are of concern, alternate scanning techniques are required.

## 7. Apparatus

7.1 Apparatus shall include the following:

7.1.1 *Electronic Equipment*—The electronic equipment shall be capable of producing and processing electronic signals at frequencies in the range of the search unit frequencies being used. The equipment and its display shall provide characteristics as listed in Table 1, that are suitable for the specific application at the specified frequency, as determined in accordance with the procedures and tolerances described in Practice E 317. The equipment, including the search unit, shall be capable of producing echo amplitudes of at least 60 % of full screen height from the reference reflector required for the examination, with the material noise level, from front to back surface not exceeding 20 % of full screen height. Alternatively, if these conditions can be met at one half the part thickness, the part may be inspected from both sides.

NOTE 1—The using parties should agree on the minimum instrument characteristics prior to conducting an examination.

7.1.2 *Voltage Regulator*—If fluctuations in line voltage cause indication amplitude variations exceeding +/– ½ dB, a voltage regulator shall be required on the power source. This requirement is not applicable to battery-operated units.

7.1.3 *Search Units*—The search unit selected shall be capable of transmitting and receiving ultrasound at the required frequencies and energy levels necessary for discontinuity detection in the material being examined. The search units shall be of the contact type. Only longitudinal wave, straight beam, non-focused search units should be used. Dual element search units may provide better near-surface resolution and detection of small discontinuities. Generally, round or rectangular search units are used for examination whereas round search units with symmetrical sound beam patterns are used for evaluation. Typical search unit sizes range from ⅛ in. (3.2 mm) in diameter to 1-⅛ in. (28.6 mm) in diameter with other sizes and shapes available for special applications. Search units may be fitted with contoured shoes to enhance coupling with curved surfaces.

7.1.4 *Alarm(s)*—For the examination of parts with regular shape and parallel surfaces such as machined cylinders, rounds, bars, forgings, etc. an audible/visual alarm may be used in conjunction with visual monitoring of the display for the detection of discontinuities or for the monitoring and detection of loss of back surface reflection, or both. The alarm should be adjustable to allow triggering at commonly required indication amplitudes, back-echo heights, and depths. During examination the audible visual alarm shall be easily detectable by the operator.

7.1.4.1 When reduction in the amplitude of back-surface reflection is monitored simultaneously with the detection of lower amplitude signals from small, discrete discontinuities, two separate gate/alarm systems are required. The negative slaved alarm system may also provide for a significantly lower receiver gain at the gated depth to avoid back-echo saturation. See 10.1 and 10.4.

7.1.4.2 For some applications it may be advantageous to utilize a flaw gate system in which the echo-amplitude alarm level can be varied as a function of target depth. Refer to distance/amplitude gate (DAG) in 9.3.2.1.

7.2 *Couplant*—A couplant, usually a liquid or semi-liquid, is required between the face of the search unit and the

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examination surface to permit transmittance of ultrasound from the search unit into the material under examination. Typical couplants include water, cellulose gel, oil and grease. Corrosion inhibitors or wetting agents or both may be used. Couplants selected must not be detrimental to the product or the process. The same couplant used for standardization shall be used for the examination. During the performance of a contact ultrasonic examination, the couplant layer between search unit and examination material must be maintained such that the contact area is held constant while maintaining adequate couplant thickness. Lack of couplant that will reduce the effective contact area, or excess couplant, will reduce the amount of energy transferred between the search unit and the examination surface. These couplant variations, in turn, result in examination sensitivity variations.

7.2.1 The couplant should be selected such that its viscosity is appropriate for the surface finish of the material to be examined. The examination of rough surfaces generally requires a high-viscosity couplant and will result in some deterioration of near-surface discontinuity detection. The temperature of the material surface can change the couplant's viscosity as in the case of oil and grease. See Table 2 for the suggested viscosity of oil couplants for given surface roughnesses.

7.2.2 At elevated temperatures as conditions warrant, heat-resistant coupling materials such as silicone oils, gels, or greases should be used. Further, intermittent contact of the search unit with the part surface or auxiliary cooling of the search unit may be necessary to avoid temperature changes that affect the ultrasonic characteristics of the search unit. At higher temperatures, certain couplants based on inorganic salts or thermoplastic organic materials, high-temperature delay materials (shoes) and search units that are not affected by high temperatures may be required.

7.2.3 Where constant coupling over large areas is required, as in automated examination, or where severe changes in surface roughness are found, other methods of coupling such as liquid gap coupling will usually provide a better examination. In this case, the search unit does not contact the examination surface, but is separated by a distance of about 0.02 in. (0.5 mm) filled with couplant. Liquid flowing through the search unit mechanism fills the gap. The flowing liquid provides the coupling path and has the additional advantage of cooling the search unit if the examination surface is warm.

7.2.4 Another means of direct contact coupling is provided by the wheel search unit. The search unit is mounted at the correct angle to a stationary axle about which rotates a liquid-filled flexible tire. A minimum amount of couplant provides for ultrasonic transmission into the examination surface since the elastic tire material is in rolling contact and conforms closely to the surface.

**TABLE 2 Suggested Viscosities-Oil Couplants**

NOTE 1—This table is a guide and is not meant to exclude the use of a particular couplant that is found to work satisfactorily on a surface.

| Approximate Surface Roughness Average (Ra) µin. (µm) | Equivalent Couplant Viscosity Weight Motor Oil |
|---|---|
| 5-100 (0.1 to 2.5) | SAE 10 |
| 50-200 (1.3 to 5.1) | SAE 20 |
| 100-400 (2.5 to 10.2) | SAE 30 |
| 250-700 (6.4 to 17.8) | SAE 40 |
| Over 700 (18+) | Cup Grease |

7.3 *Reference Standards*—The production item itself may be an adequate standard using the height of the back-wall echo for reference. For more quantitative information, charts such as (AVG-DGS) representing distance-amplitude relationships of known reflector sizes for a particular search unit, frequency and material may be used for standardization and evaluation of discontinuities.

7.3.1 *Reference Blocks*—Ultrasonic reference blocks, often called test blocks, are used to standardize the ultrasonic equipment and to evaluate the indications received from discontinuities within the part. The ultrasonic characteristics of the reference blocks such as attenuation, noise level, surface condition, and sound velocity, should be similar to the material to be examined. Standardization verifies that the instrument search unit is performing as required and establishes a detection level for discontinuities.

7.3.2 *Flat Blocks*—The three most commonly used sets of reference block are area-amplitude set, containing blocks with the same material path and various sizes of reference reflectors; distance-amplitude set, containing blocks with one size reference reflector at various material distances; and a combination including both area-amplitude and distance-amplitude blocks in one set. These sets are described in Practices E 127 and E 428.

7.3.3 *Curved Surfaces*—Reference blocks with flat surfaces may be used for establishing gain settings for examinations on concave test surfaces and convex surfaces with radii of curvature 4 in. (101.6 mm) or greater. For convex surfaces with radii of curvature less than 4 in. (101.6 mm) it is recommended that reference blocks with approximately the same nominal radius of curvature shall be used. Guide E 1158 illustrates typical curved entry surface blocks.

7.4 *Reference Reflectors*—Flat-bottomed holes, (FBH), or other artificial discontinuities, located directly in the material, in a representative sample of the part or material, or in reference blocks, should be used to reference echo amplitude or to perform distance-amplitude correction (DAC), or both. For most examinations, the bottom surface of a suitable flat-bottom hole is the common reference reflector. However, other types of artificial discontinuities (notches, side-drilled holes, areas of unbond or lack of fusion, etc.) may be used.

## 8. General Examination Requirements

8.1 *Material Condition*—Unless otherwize agreed upon, the surface finish of the article under examination shall not exceed 250 µin. (6.4 µm) rms and shall be free from waviness that may affect the examination. Ultrasonic examination should be performed in the simplest configuration possible and after all operations that may cause a discontinuity. Examinations of parts or material prior to machining is acceptable provided surface roughness and part geometry are within the tolerance specified in the written procedure. When it is determined that surface roughness or waviness, or both, precludes adequate detection and evaluation of subsurface discontinuities, smooth the areas in question by machining, grinding, or other means

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prior to the examination. During examination and evaluation ensure that entry surface free from loose scale, grinding particles, or other loose matter.

8.2 *Coverage*—In all examinations, perform scanning to locate discontinuities that are oriented parallel with the entry surface, or plane, or both, approximately normal to the major propagation direction that is parallel to the grain flow of the part.

8.3 *Resolution and Penetration*—When the complete calibration and examination cannot be accomplished due to excessive noise levels (based on 3:1 signal-to-noise ratio) or material thicknesses, the examinations shall be performed from opposite sides. Examinations conducted from opposite sides shall provide for examination of a minimum of one-half material thickness and shall provide for the resolution and penetration necessary to detect the minimum size reflector at the minimum and maximum metal path distance.

8.4 *Ultrasonic Frequency*—In general, the higher frequencies provide a more directive sound beam and provide better resolution throughout the material cross section. The lower frequencies provide better penetration and better detection of misaligned planar discontinuities. For a particular examination select the frequency based on the material, the anticipated type of discontinuities, and other specified examination requirements.

## 9. Standardization of Equipment

9.1 Prior to examination, standardize the system in accordance with the written procedure. Reference standard material travel distance is normally selected for the thickness to be examined, or in the case of large cross sections, half-thickness tests from opposing entry surfaces may be more appropriate. Reference standards may be selected from the distance-amplitude sets listed in Practice E 127 or Practice E 428 or may be fabricated as illustrated in Guide E 1158.

9.2 Where there is a difference in acoustic attenuation between the reference block and the production item, an attenuation correction is required to compensate for the difference. The attenuation correction is accomplished by noting the difference between signals received from the back surfaces of the reference block and the production material having equal thickness, and correcting for this difference.

9.3 *Initial Standardization*:

9.3.1 Standardization using the production part as the reference standard. Examinations may be conducted using the production part as the reference standard. This technique generally applies to simple solid shapes with parallel or diametrically opposing surfaces. Using the gain control, the amplitude of the initial back echo reflection is established as a percent of full screen height, normally 80 %, and this setting is used to examine the part. This technique is suitable for the detection of planar discontinuities generally parallel to the entry surface and having a minimum extent equal to an appreciable fraction of the cross sectional area of the transducer beam.

9.3.1.1 For some materials, attenuation curves on overlays that fit over the display, and charts, such as (AVG/DGS) showing distance-amplitude relationships of known reflectors are available. These techniques utilize information derived theoretically or empirically and are specific to search unit size and frequency. The AVG-DGS system provides a summary of the anticipated behavior of small and large reflectors and can be used to analyze the reflecting area of discontinuities as compared to the back-echo reflection.

9.3.2 *Standardization*—Determine the distance amplitude relationship for the required set of distance-amplitude reference blocks by positioning the search unit over the reference block that provides the greatest amplitude response from the reference reflector. Adjust the instrument controls (for the instruments so equipped) ie: pulse length, pulse repetition rate, damping, frequency, and tuning to achieve the required resolution. The reject control shall be in the off position. Maximize, the indication from the reference block which provides the greatest amplitude response from the reference reflector by carefully positioning the transducer; adjust the gain control to set the amplitude response at 80 % of the upper vertical linearity limit. Without changing the instrument controls, maximize the amplitude of the reference reflector from each of the remaining reference blocks in the set and mark their amplitude and horizontal sweep positions on the display. Connect these points to form a curve. A typical distance amplitude curve is shown in Fig. 1.

NOTE 2—A common practice is to connect the adjacent amplitude points with straight lines. Normally, the curve is extrapolated to form a smooth curve or a straight line continuing at the same slope as the previous data points until meeting the base line.

9.3.2.1 *Distance/Amplitude Gate (DAG)*—If the instrumentation includes a flaw-gate alarm system in which the alarm threshold can be time-varied as a function of target depth, the gate can serve both as an alarm and means for distance-amplitude compensation. The alarm level is adjusted to correspond to the distance-amplitude curve established by the procedure in 9.3.2. The method used depends on the specific features provided and the related operational instructions. In a system which directly displays the alarm level on an alternate trace at the corresponding screen amplitude, then it is (only)

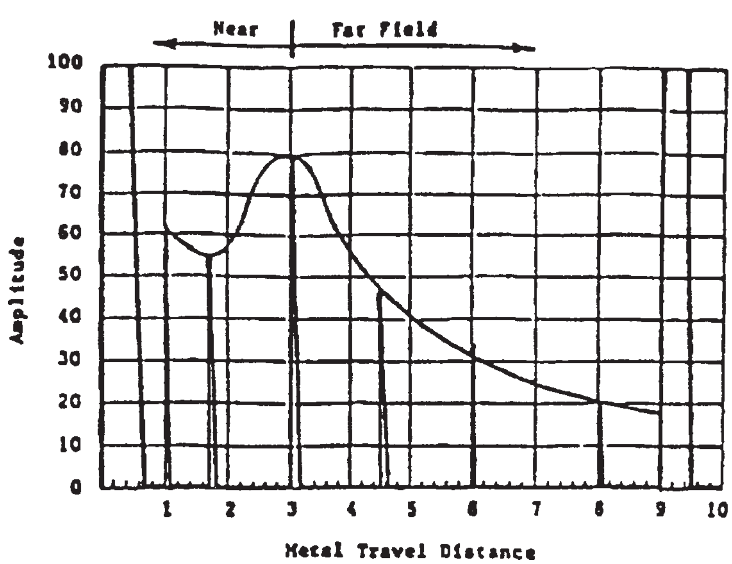


FIG. 1 Typical Calibration Curve

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necessary to adjust this trace to coincide with the curve previously marked on the display.

9.3.3 *Standardization with Distance-Amplitude Compensation*—This is achieved by the use of electronic circuitry referred to as: time-variable amplifier gain typically called distance amplitude correction (DAC), distance echo correction (DEC), time varying gain (TVG), time corrected gain (TCG), or sensitivity time control (STC). Following the manufacturer's instructions for the specific instrumentation, adjust the instrument controls so that the indication amplitude of the reference reflector from each block is approximately equal. Normally, the amplitude for the reflector from the block with the lowest response is set at 80 % of the upper vertical linearity limit using the gain control and all the other responses are adjusted using the electronic circuitry controls.

9.4 It should be recognized that near-field effects may cause sensitivity inconsistencies when searching for discontinuities smaller than the effective beam diameter. Suitable delay-line search units, or other means such as examination from opposite sides of the item, should be considered where the application requires close scrutiny. When performing examinations in the far field, it is recommended that compensation be made for the acoustic attenuation of the material with respect to the reference standard used to set the inspection sensitivity. For optimum examination performance, compensation should be made for both near-, and far-field effects.

9.5 For bond/unbond (fusion/lack of fusion) examinations, a reference standard shall be used that is geometrically and acoustically similar to the production item being examined and shall contain areas representing both bond (fused) and unbonded (not fused).

9.6 Standardization with respect to reference standards shall be checked periodically to ensure that the ultrasonic system is not changing. As a minimum, the system shall be checked each time that there is a change in operators, search unit, cable, power source (including new batteries) or when equipment malfunction is suspected.

9.6.1 Criteria shall be established for acceptable rechecks and equipment not meeting the criteria shall be removed from service. All material examined since the last acceptable recheck shall be re-examined.

## 10. Procedure

10.1 The initial pulse and at least one back reflection shall appear on the display while examining for discontinuities in materials having parallel surfaces and diametrically opposing surfaces. The total number of back reflections depends on equipment, geometry and material type, information desired, or operator preference. Reduction of an (unsaturated) back reflection or the (multiple back reflection pattern), during scanning is indicative of increased attenuation or scattering of the sound beam by discontinuities, provided that the front and back surface roughness and parallelism of the production piece is approximately the same as that of the standard. A back-gated attenuator may be used to provide an unsaturated back reflection during high-sensitivity examinations.

10.2 *Examination Surface*—Surfaces shall be uniform in surface finish and free of loose scale and paint, weld spatter dirt, machining chips, and other foreign material. Waviness, pits, gouges, and handling marks shall be such as to not interfere with the examination. Tightly adhering paint, scale, or coatings may not necessarily need to be removed provided they present uniform attenuation characteristics. The examination surface must be adequate to permit ultrasonic examination at the specified sensitivity. If necessary, surfaces may be ground, sanded, wire brushed, scraped, or otherwise conditioned for the examination. Curved surfaces, either convex or concave may be examined, however, the standardization system should compensate for the effective change in the examination area, and the propagation of a range of refraction angles in the material, as compared to a flat reference standard.

10.3 *Search Unit*—The search unit frequency, unless otherwise specified is selected to provide the resolution and penetrability required for the examination. The acoustic properties of the material and the minimum size and type of discontinuity must be considered when selecting frequency. Higher frequencies will provide greater sensitivity and resolution capabilities, but lesser penetration power; conversely, lower frequencies provide greater penetration power, but lesser sensitivity and resolution. Factors limiting the use of higher frequencies are the equipment and material properties. Use of lower frequencies is limited primarily by the loss of sensitivity. Geometry of the part is the primary consideration for selecting the size of the search unit; however, like frequency, the size of the search unit also effects resolution and length of the near and far fields. Various types of straight-beam search units are commercially available offering advantages for specific applications. The above statements should be considered when choosing the search unit size, type, and frequency. When delay materials are used in the search unit, the standards and the examination surface temperatures should be maintained within 25°F (14°C) to avoid large attenuation and velocity differences.

NOTE 3—The largest diameter and highest frequency search units yielding the desired results should be used for maximum resolution and good beam directivity.

10.4 *Scanning*—Scanning is accomplished using the same instrument settings as used for standardization. Scanning may be either continuous or intermittent, depending on the geometry, application, and specific requirements for the part being examined. For continuous scanning, the search unit indexing or overlap must be adequate to provide for 100 % coverage, at an examination sensitivity throughout the thickness of the part that does not vary more than 10 % from that determined by optimizing on each of the reference reflectors. Monitor coupling of the search unit to the part visually by continually monitoring the display presentation. Adjust scanning speed or pulse repetition rate, or both, to permit detection of the smallest discontinuity referenced in the applicable specification. When desired or required, set the threshold level of the discontinuity alarm at an agreed level below that of the reference response or exceeding a present threshold level of the discontinuity alarm.

10.4.1 *Back-Reflection Monitor*—If desired or required the back reflection may be monitored by adjusting the back-reflection echo at an amplitude in the unsaturated range (on display). This adjustment may be accomplished using the gain

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adjustment or with instruments so equipped, using the back echo gain adjustment that is normally part of the back echo alarm circuitry.

10.4.2 *Manual Scanning*—Parts may require 100 % volumetric examination or may require examination only in specified areas. For the area to be examined, mark the part into grids. Hold the search unit in the hand and move over the surface of the production piece, index the search unit, and continue until the entire grid has been scanned. Place an "X" in the grid indicating completion and scan the next grid. Continue until the entire part has been scanned.

10.4.3 *Automatic Scanning*—The search unit is held by a suitable device and the production part is scanned along a predetermined path, by holding the part stationary while moving the search unit, or by moving the part in relation to a stationary search unit, or both. For automatic scanning, monitor coupling between the search unit and the part by monitoring the noise level or the back-echo amplitude, or both, or back-echo pattern.

10.4.3.1 *Recorders*—Automatic scanning systems may provide A-Scan, B-Scan, and C-Scan recordings of the examination results with sufficient accuracy to permit locating the regions of a part, from which indications were obtained, without actually placing a mark on the part.

10.4.4 *Indications*—As scanning progresses, mark on the part the locations of indications having amplitudes greater than one half of the reference response, or exceeding the threshold of the discontinuity alarm.

10.4.5 *Loss of Back Reflection*—As scanning progresses mark on the part the locations at which the back reflection is below the specified value. Determine that the loss of back reflection is not caused by part geometry or local surface roughness. Local surface roughness shall be conditioned in accordance with 8.1.

## 11. Evaluation of Discontinuities

11.1 When ultrasonic examinations are performed for the detection or evaluation of discontinuities, or both, reflectors not perpendicular to the ultrasonic beam may be detected at reduced amplitudes, with a distorted envelope depending upon the reflective area, whether it is curved or planar, whether it is smooth or rough, perhaps with reflecting facets. Reflector characteristics may also cause rapid shifts in apparent depth as the search unit approaches or moves away from the low-amplitude indication. Another effect of these reflectors is the loss of back surface reflection which occurs when the discontinuity lies directly between the search unit and the back surface. Reflectors detectable due to any of the foregoing phenomena cannot be evaluated solely on signal amplitude and may require evaluation using different frequencies and angled waves in order to obtain the maximum extent of the discontinuity.

11.2 During the evaluation of indications, maintain the same relative gain between the reference standard and the production part. Make an evaluation of indications after obtaining the depth and the maximum obtainable amplitude response from the discontinuity. Indications are normally evaluated by comparing the amplitude response from the discontinuity with the amplitude of a known reference reflector having approximately the same material distance.

11.2.1 The known reference reflector may be contained in a reference block, may be machined in the part under test or may be the part itself. The actual reflector may be a flat-bottomed hole, side-drilled hole, or notches. The reference reflector may also be the initial back echo or back echo pattern obtained from the part under test. Charts and curves, such as AVG-DGS may be used to compare amplitude indications from two reflectors when using the back-reflection technique.

11.3 Map discontinuity extremities larger than the search unit size. The half-amplitude technique is recommended for mapping the apparent size (that is the reflecting surface seen by the search unit) of discontinuities larger than the search unit. To perform this technique, position the search unit over the discontinuity such that maximum signal is obtained and note the amplitude. Move the search unit in one direction until the signal drops rapidly to the baseline on the display. Move the search unit back along the same path until the signal rises to one half of the maximum amplitude that was noted. Place a mark on the part to coincide with the center position of the search unit; this mark will also coincide with the approximate edge of the discontinuity. Repeat this procedure for other directions as necessary to outline the discontinuity on the surface of the part. Search units of different sizes and frequencies may be used for mapping to obtain greater accuracy. Special consideration shall be given to discontinuities when the signal amplitude drops to half the maximum amplitude and less, and remains at the lower amplitude over extended distances (for example; more than half the search unit diameter) and continuous discontinuities that move horizontally along the base line (change in depth) as the search unit is scanned along the part.

## 12. Report

12.1 Document specific examination requirements, procedural details, and results for a particular examination in written contractual agreements, procedures, and reports. Include the following items in the examination report:

12.1.1 Part identification,

12.1.2 Operator's name and certification level,

12.1.3 Disposition of part and disposition date,

12.1.4 Instrument make, model, and serial number,

12.1.5 Search unit make, model, serial number, frequency, and diameter,

12.1.6 Couplant, cable type and length, manual/automatic scanning,

12.1.7 Reference standard serial number(s), material travel(s) and flat-bottomed hole size(s),

12.1.8 Standardization levels,

12.1.9 Procedure identification and acceptance criteria applied,

12.1.10 Attenuation correction, if applicable, and

12.1.11 Description of indications detected; number, type, estimated size (minimum), length, depth, and location. For unbond and lack of fusion examinations report extent of unbond/lack of fusion as percent of total surface area.

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## 13. Keywords

13.1 contact; evaluation; examination; procedure; pulse-echo; straight-beam; ultrasonic

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