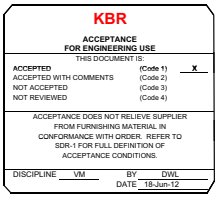
KBR	KEMPER COUNTY IGCC UNIT 1 PROJECT	SOUTHERN COMPANY

NDE PROCEDURE

ITEM NAME : Selexol Flash, KO & Reflux Drum

(ITEM NO : DR1060 / 2060, DR1061 / 2061, DR1062 / 2062, DR1063 / 2063, DR1064 / 2064, DR1065 / 2065, DR1080 / 2080,DR1168 /2168/1268/2268)



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NDE Procedure Content

Ⅰ. Radiographic Examination Procedure

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1. Scope

1.1 This procedure will be applied to the radiographic examination of welds for pressure vessel, power boiler, power piping, and welder qualification.

1.2 This procedure describes the general requirements for safety, materials, equipment, personnel, technique, and acceptance criteria. When differences exist between this procedure and technical specification, the technical specification shall govern.

2. References

2.1 ASME Sec. Ⅰ Power Boilers (2007 Edition)

2.2 ASME Sec. V Nondestructive Examination (2007 Edition-2009ADD)

2.3 ASME Sec. Ⅷ Div 1. & 2. Rules for construction of Pressure Vessels (2007 Edition-2009ADD)

2.4 ASME Sec. Ⅸ Welding and Brazing Qualification (2007 Edition-2009ADD)

2.5 ASME B31.1 Power Piping (2007 Edition-2009ADD)

2.6 ASNT Recommended Practice No. SNT-TC-1A for NDT Personnel Qualification and Certification. (2006 Edition)

3. General Requirements

3.1 This procedure meets the requirements of ASME Section Ⅰ, V, Ⅷ (Div. 1 & Div. 2), Ⅸ, and ASME B31.1

3.2 Examination shall be conducted at the time specified on the related applicable drawings prepared including weld configuration with thickness, dimension, and base material product from in accordance with the referencing Code section.

3.3 The extent of examination will be designated by the customer or his representative. Unless otherwise specified, the extent of radiograph coverage shall include 100% of the volume of the weld and adjacent base material.

3.4 Personnel Qualification

1) Personnel shall be qualified and certified in accordance with the employer written practice that shall meet SNT-TC-1A.

2) Only qualified and certified Level Ⅱ or Level Ⅲ Personnel shall make determinations to the acceptability of examination results.

3.5 Specification Requrirements

1) General Requirements

(a) When weld sheam covered

The weld seams that will be partially or wholly covered shall be carefully ground flat and smooth ensuring there are no undercut and 100% radiographed for the length of the weld to be covered, plus 80 mm at each end, prior to covering the weld. This requirement applies whether it is the interior surface or the exterior surface of the weld that will be covered.

(b) When forming occurs after completion of welding

The specified radiography or other nondestructive examination may occur after welding but prior to forming. If so, an additional liquid penetrant or magnetic particle examination of all surfaces is required after forming.

(c) When postweld heat treatment (PWHT) is required, the specified radiography of welds shall be performed after PWHT. If radiography is performed before PWHT, an additional radiographic examination shall be performed after PWHT.

(d) Spot Radiography

Where Spot Radiography is specified, the examination shall include a minimum of ten percent (10%) of the total length of weld. Spots shall be selected so that each welder, each welding process and each longitudinal and circumferential seam is represented in the examination. All requirements specified for Spot Radiography in ASME Section VIII must also be met. The CONTRACTOR'S inspector must agree to the spot locations.

Each spot radiograph shall be a minimum of six inches (150 mm) in length. Welds from each welding procedure, welder/welding operator, and shift shall be examined.

When spot radiographic examination, in accordance with ASME Section VIII UW-52, results in a rejected increment of weld, according to Para.7.2 of this procedure, a new increment of weld, welded by the same welder or operator to the same WPS shall be immediately selected for spot radiographic examination. The location(s) of the additional spot radiograph(s) shall be agreed to by the CONTRACTOR. If this spot radiography results in a rejected increment of weld, the welder or welding operator shall be considered unacceptable for any further welding to that WPS with respect to the CONTRACTOR'S work done to this specification without requalification and the agreement of the CONTRACTOR.

Timing is essential for the control of welder or operator quality; therefore, the second increment of weld radiography shall be completed within one day of the first rejection, unless otherwise agreed to by the CONTRACTOR.

2) Requirement of Cr-Mo alloy steel high pressure equipment

All pressure-retaining butt welds and vessel to support skirt welds shall be fully examined by RT in accordance with ASME Section VIII, Div. 2, Article I-5 before final PWHT. When RT is not practical for nozzle welds and skirt attachment welds, UT may be applied in lieu of RT Ultrasonic Testing may be preformed in lieu of Radiographic Testing, subject to the conditions defined in UT procedure.

All pressure-retaining butt welds and vessel to support skirt welds shall be fully examined by RT in accordance with 2007Edition through 2009 Addenda of ASME Section VIII, Div.2 Para.7.5.3, before final PWHT

3) Design pressure exceeds 1000 psig {70 kg/cm^2(g)} or the vessel is in HF acid service

All pressure containing welds, including nozzle to vessel welds, shall be 100% radiographed.

4) Low alloy steel

All pressure containing welds shall be 100% radiographically examined. Nozzle welds that cannot be radiographed shall be 100% ultrasonically examined.

5) ASME Section Divitsion 2 vessels

All weld repairs extending deeper than 3/8 inch (10 mm) from the surface shall be 100 percent examined both by radiographic and ultrasonic means. A record of all such repairs shall be maintained. All pressure containing welds shall be 100 percent radiographically examined. Nozzle welds that cannot be radiographed shall be 100 percent ultrasonically examined.

6) Vessels with shell thickness greater than 50mm

The following welds shall be 100% radiographed:

- All seams in shell and heads.
- Attachment welds of manways and all nozzles greater than 2” N.B constructed to Division 1 with shells greater than 75 mm in thickness and in all vessels constructed to Division 2.
- Built-up weld deposits in vessels constructed to Division 2 and the attachment weld between the vessel and its support skirt in vessels constructed to Division 2.
- For vessels constructed to Division 2, all seams in support skirt (or portions of skirts) made of other than P-1 materials, including the seam joining a non P-1 material skirt section to a P-1 material section.
- For vessels constructed to Division 1 and those portions of vessels constructed to Division 2 not covered by (d) above, skirt welds shall be radiographed for 10% of their length (locations chosen at random), except standards for acceptance shall be in accordance with 100% radiography.

- Repair welds made to any of the above welds.

4. Equipment and Materials

4.1 Radiation Energy

1) X-ray machines maximum voltage 300kvp or radioactive isotopes, such as Ir-192 shall be used. The minimum voltage used in the examination shall not exceed the value shown in equipment manufacture's instruction manual for applicable materials and thickness.
The radiation energy used for any radiographic technique shall achieve the density and IQI image requirement of this procedure.

2) Verification of Source Size
The equipment manufacturer's or supplier's publications, such as technical manuals, decay curves, or written statements documenting the actual or maximum source size or focal spot, shall be acceptable as source size verification.
-Maximum focal spot of X-ray : 2.5 ㎜ × 2.5 ㎜
-Maximum source size Ir-192 : 3.0 ㎜ × 3.5 ㎜
-Maximum source size Co-60 : 4mm×6.2mm

3) Direction of Radiation
The direction of the central beam of radiation should be centered on the area of interest whenever practical.

4.2 Film

1) Selection
Radiographs shall be made using industrial radiographic film. The film brands and designations used are as follows.

Film Type	Film Brand	Film Designation
Type Ⅰ	FUJI KODAK	# 50, #80 M, T
Type Ⅱ	FUJI KODAK	# 100 AA

2) Processing
Standard Guide for Controlling the Quality of Industrial Radiographic Film Processing, SE-999, or paragraphs 23 through 26 of Standard Guide for Radiographic Examination SE-94 shall be used as a guide for processing film.

3) Radiographic film length shall be 250mm(10Inches) minimum

4.3 Screens

Lead intensifying screens shall be used and directly contacted with the film. The front and back screens shall be minimum 0.005 in. thickness used.

4.4 Backscatter Radiation

A lead symbol “B” with minimum dimensions of 1/2 in. (13 ㎜) in height and 1/16 in. (1.6 ㎜) in thickness, shall be attached to the back of each film holder during each exposure to determine if backscatter radiation is exposing the film.

4.5 Image Quality Indicator (IQI) Design

1) Standard IQI Design

IQIs shall be either the hole type or wire type. Hole type IQIs shall be manufactured and identified in accordance with the requirements or alternates allowed in SE-1025. Wire type IQIs shall be manufactured and identified in accordance with the requirements or alternates allowed in SE-747, except that the largest wire number or the identity number may be omitted. ASME standard IQIs shall consist of those in Table 1 for hole type and those in Table 2 for wire type.

4.6 System of Identification

A system shall be used to produce permanent identification on the radiograph traceable to the contract, component, weld or weld seam, or part numbers, as appropriate. In addition, the Manufacturer’s symbol or name and the date of the radiograph shall be plainly and permanently included on the radiograph. This identification system does not necessarily require that the information appear as radiographic images. In any case, this information shall not obscure the area of interest.

4.7 Densitometer and Step Wedge Comparison Film

1) Densitometers

Densitometers shall be calibrated at least every 90 days during use as follows:

(a) A national standard step tablet or a step wedge calibration film, traceable to a national standard step tablet and having at least 5 steps with neutral densities from at least 1.0 through 4.0, shall be used. The step wedge calibration film shall have been verified within the last year by comparison with a national standard step tablet unless, prior to first use, it was maintained in a light-tight and waterproof sealed package as supplied by the manufacturer. Step wedge calibration films may be used without verification for one year upon opening, provided it is within the manufacturer's stated shelf life.

(b) The densitometer manufacturer's step-by-step instructions for the operation of the densitometer shall be followed

(c) The density steps closest to 1.0, 2.0, 3.0, and 4.0 on the national standard step tablet or step wedge calibration film shall be read.

(d) The densitometer is acceptable if the density readings do not vary by more than ±0.05 density units from the actual density stated on the national standard step tablet or step wedge calibration film.

2) Step Wedge Comparison Films

Step wedge comparison films shall be verified prior to first use, unless performed by the manufacturer, as follows:

(a) The density of the steps on a step wedge comparison film shall be verified by a calibrated densitometer.

(b) The step wedge comparison film is acceptable if the density readings do not vary by more than ±0.1 density units from the density stated on the step wedge comparison film.

3) Periodic Verification

(a) Densitometers

Periodic calibration verification checks shall be performed as described in 4.7 1) at the beginning of each shift, after 8 hr of continuous use, or after change of apertures, whichever comes first. The densitometer is acceptable if the density readings are within ±0.05 of the calibration readings determined in 4.7 1) (c).

(b) Step Wedge Comparison Films.

Verification checks shall be performed annually per 4.7 2).

4) Documentation

(a) Densitometers

Densitometer calibrations required by 4.7 1) shall be documented, but the actual readings for each step do not have to be recorded. Periodic densitometer verification checks required by 4.7 3) (a) do not have to be documented.

(b) Step Wedge Calibration Films

Step wedge calibration film verifications required by 4.7 1) (a) shall be documented, but the actual readings for each step do not have to be recorded.

(c) Step Wedge Comparison Films

Step wedge comparison film verifications required by 4.7 2) and 4.7 3) (b) shall be documented, but the actual readings for each step do not have to be recorded.

4.8 Cassette

Flexible PVC or rubber type cassette shall be used and film holders shall be light tight.

4.9 Facilities for Viewing of Radiographs

Viewing facilities shall provide subdued background lighting of an intensity that will not cause reflections, shadows, or glare on the radiograph that interfaced with the interpretation. Equipment used to view radiographs for interpretation shall provide a variable light source sufficient for the essential IQI hole or designated wire to be visible for the specified density range. The viewing conditions shall be such that light from around the outer edge of the radiograph or coming through low-density portions of the radiograph does not interfere with interpretation.

4.10 Shims under hole IQI

A Shim of material radiographically similar to the weld metal being examined shall be used as prescribed herein. The shim dimensions shall exceed the IQI dimensions such that the outline of at least three sides of the IQI image shall be visible in the radiograph.

5. Examination

5.1 Surface preparation

1) Materials

Surfaces shall satisfy the requirements of the applicable materials specification or referencing Code Section, with additional conditioning, if necessary, by any suitable process to such a degree that the resulting radiographic image due to any surface irregularities cannot mask or be confused with the image of any discontinuity.

2) Welds

The weld ripples or weld surface irregularities on both the inside (where accessible) and outside shall be removed by any suitable process to such a degree that the resulting radiographic image due to any surface irregularities cannot mask or be confused with the image of any discontinuity. The finished surface of all butt-welded joints may be flush with the base material or may have reasonably uniform crowns, with reinforcement not to exceed that specified in the Referencing Code Section.

5.2 Radiographic Technique

A singe-wall exposure technique shall be used for radiography whenever practical. When it is not practical to use a single-wall technique, a double wall technique shall be used. An adequate number of exposures shall be made to demonstrate that the required coverage has been obtained.

A) Single-Wall Technique

In the single wall technique, the radiation passes through only one wall of the weld(material), which is viewed for acceptance on the radiograph.

B) Double-Wall Technique

When it is not practical to use a singe-wall technique, one of the following double-wall techniques shall be used.

1) Singe-Wall Viewing

For materials and for welds in components, a technique may be used in which the radiation passes through two walls and only the weld (material) on the film-side wall is viewed for acceptance on the radiograph. When complete coverage is required for circumferential welds(materials), a minimum of three exposures taken 120 deg. to each other shall be made.

2) Double-Wall Viewing

For materials and for welds in components 3-1/2 in. (89 ㎜) or less in nominal outside diameter, a technique may be used in which the radiation passes through two walls and the weld(material) in both walls is viewed for acceptance on the same radiograph. For double-wall viewing, only a source-side IQI shall be used. Care should be exercised to ensure that the required geometric unsharpness is not exceeded. If the geometric unsharpness requirement cannot be met, then singe-wall viewing shall be used.

(a) For welds, the radiation beam may be offset from the plane of the weld at an angle sufficient to separate the images of the source-side and film-side portions of the weld so that there is no overlap of the areas to be interpreted. When complete coverage is required, a minimum of two exposures taken 90 deg. to each other shall be made for each joint.

(b) As an alternative, the weld may be radiographed with the radiation beam positioned so that the images of both walls are superimposed. When complete coverage is required, a minimum of three exposures taken at either 60 deg. or 120 deg. to each other shall be made for each joint.

(c) Additional exposure shall be made if the required radiographic coverage cannot a be obtained using the minimum number of exposures indicated in (a) or (b) above.

5.3 Location Markers

Location Markers (Fig.1, 2), which are to appear as radiographic images on the film, shall be placed on the part, not on the exposure holder/cassette. Their locations shall be permanently marked on the surface of the part being radiographed when permitted, or on a map, in a manner permitting the area of interest on a radiograph to be accurately traceable to its location on the part, for the required retention period of the radiograph.

Evidence shall also be provided on the radiograph that the required coverage of the region being examined has been obtained. Location markers shall be placed as follows.

1) Singe-Wall Viewing

(1) Source-Side Markers

Location markers shall be placed on the source side when radiographing the following:

(a) flat components or longitudinal joints in cylindrical or conical components;

(b) curved or spherical components whose concave side is toward the source and when the "source-to-material" distance is less then the inside radius of the component;

(c) curved or spherical components whose convex side is toward the source.

(2) Film-Side Markers

(a) Location markers shall be placed on the film side when radiographing either curved or spherical components whose concave side is toward the source and when the “source-to-material” distance is greater than the inside radius.

(b) As an alternative to source-side placement in 1) (1) (a) above, location markers may be placed on the film side when the radiograph shows coverage beyond the location markers to the extent demonstrated by Fig. 2, sketch (e). and when this alternate is documented in accordance with this procedure para. 9.1.

(3) Either Side Markers

Location markers may be placed on either the source side or film side when radiographic either curved or spherical components whose concave side is toward the source and the “source-to-material”distance equals the inside radius of the component.

2) Double-Wall Viewing

For double-wall viewing, at least one location marker shall be placed adjacent to the weld (or on the material in the area of interest) for each radiograph.

3) Mapping the Placement of Location Markers.

When inaccessibility or other limitations prevent the placement of markers as stipulated in 1) and 2) above, a dimensioned map of the actual marker placement shall accompany the radiographs to show full coverage has been obtained.

4) A starting position (1-2), each weld will begin with 1 as the first location marker, shall be selected for each weld being radiographed. The direction of numbering of location markers shall be permanently identified by metal chalk or painting (pipe welds only) adjacent to the weld.

5.4 IQI Selection

1) Material

IQIs shall be selected from either the same alloy material group or grade as identified in SE-1025, or SE-747, as applicable. or from an alloy material group or grade with less radiation absorption than the material being radiographed.

2) Size

The designated hole IQI or essential wire shall be as specified in Table 3. A thinner or thicker hole-type IQI may be substituted for any section thickness listed in Table 3, provided an equivalent IQI sensitivity is maintained. (See 6.3 2)).

(1) Welds With Reinforcements

The thickness on which the IQI is based is the nominal singe-wall thickness plus the estimated weld reinforcement not to exceed the maximum permitted by the referencing Code Section. Backing rings or strips shall not be considered as part of the thickness in IQI selection. The actual measurement of the weld reinforcement is not required.

(2) Welds Without Reinforcements

The thickness on which the IQI is based is the nominal single-wall thickness. Backing rings or Strips shall not be considered as part of the weld thickness in IQI Selection.

3) Welds Joining Dissimilar Materials or Welds With Dissimilar Filler Metal

When the weld metal is of an alloy group or grade that has a radiation attenuation that differs from the base material, the IQI material selection shall be based on the weld metal and be in accordance with 1) above. When the density limits of 6.2 2) cannot be met with one IQI, and the exceptional density area(s) is at the interface of the weld metal and the base metal, the material selection for the additional IQIs shall be based on the base material and be in accordance with 1) above.

5.5 Placement of IQIs

1) Source-Side IQI(s)

The IQI(s) shall be placed on the source side of the part being examined, except for the condition described in 2) below.

When, due to part or weld configuration or size, it is not practical to place the IQI(s) on the part or weld, the IQI(s) may be placed on a separate block. Separate blocks shall be made of the same or radiographically similar materials (as defined in SE-1025) and may be used to facilitate IQI positioning. There is no restriction on the separate block thickness, provided the IQI/area-of-interest density tolerance requirements of 6.2 2) are met.

(1) The IQI on the source side of the separate block shall be placed no closer to the film than the source side of the part being radiographed.

(2) The separate block shall be placed as close as possible to the part being radiographed.

(3) When hole-type IQIs are used, the block dimensions shall exceed the IQI dimensions such that the outline of at least three sides of the IQI image shall be visible on the radiograph.

2) Film-side IQI(s)

Where inaccessibility prevents hand placing the IQI(s) on the source side, the IQI(s) shall be placed on the film side in contact with the part being examined. A lead letter “F” shall be placed adjacent to or on the IQI(s), but shall not mask the essential hole where hole IQIs are used.

3) IQI Placement for Welds - Hole IQIs

The IQI(s) may be placed adjacent to or on the weld. The identification number(s) and, when used, the lead letter “ F,” shall not be in the area of interest, except when geometric configuration makes it impractical.

4) IQI Placement for welds - Wire IQIs

The IQI(s) shall be placed on the weld so that the length of the wires is perpendicular to the length of the weld. The identification numbers and when used, the lead letter “F,” shall not be in the area of interest, except when geometric configuration makes it impractical.

5) IQI Placement for Material other than Welds

The IQI(s) with the IQI identification number(s), and, when used, the lead letter “F,” may be placed in the area of interest.

5.6 Number of IQIs

When one or more film holders are used for an exposure, at least one IQI image shall appear on each radiograph except as outlined in 2) below.

1) Multiple IQIs

If the requirements of 6.2 are met by using more than one IQI, one shall be representative of the lightest area of interest and the other the darkest area of interest; the intervening densities on the radiograph shall be considered as having acceptable density.

2) Special Cases

(1) For cylindrical components where the source is placed on the axis of the components for a single exposure, at least three IQIs, spaced approximately 120 deg. apart, are required under the following conditions:

(a) When the complete circumference is radiographed using one or more film holders, or,

(b) When a section or sections of the circumference, where the length between the ends of the outermost sections span 240 or more deg., is radiographed using one or more film holders. Additional film locations may be required to obtain necessary IQI spacing.

(2) For cylindrical components where the source is placed on the axis of the components for a single exposure, of at least three IQIs, with one placed at each end of the span of the circumference radiographed and one in the approximate center of the span, are required under the following conditions:

(a) When a section of the circumference, the length of which is greater than 120 deg. and less than 240 deg., is radiographed using just one film holders, or;

(b) When a section or sections of the circumference, where the length between the ends of the outermost sections span less than 240 deg., is radiographed using more than one film holder.

(3) In (1) and (2) above, where sections of longitudinal welds adjoining the circumferential weld are radiographed simultaneously with the circumferential weld, an additional IQI shall be placed on each longitudinal weld at the end of the section most remote from the junction with circumferential weld being radiographed.

(4) For spherical components where the source is placed at the center of the component for a single exposure, at least three IQIs, spaced approximately 120 deg. apart, are required under the following conditions:

(a) When a compete circumference is radiographed using one or more film holders, or.

(b) When a section or sections of a circumference. where the length between the ends of the outermost sections span 240 or more deg., is radiographed using one or more film holders. Additional film locations may be required to obtain necessary IQI spacing.

(5) For spherical components where the source is placed at the center of the component for a single exposure, at least three IQIs, with one placed at each end of the radiographed span of the circumference radiographed and one in the approximate center of the span, are required under the following conditions:

(a) When a section of the circumference, the length of which is greater than 120 deg. and less than 240 deg. is radiographed using just one film holder, or;

(b) When a section or sections of the circumference, where the length between the ends of the outermost sections span less than 240 deg. is radiographed using more than one film holder.

(6) In (4) and (5) above, where other welds are radiographed simultaneously with the circumferential weld, one additional IQI shall be placed on each other weld.

(7) When an array of components in a circle is radiographed, at least one IQI shall show on each component image.

(8) In order to maintain the continuity of records involving subsequent exposures, all radiographs exhibiting IQIs that quality the techniques permitted in accordance with (1) through (6) above shall be retained.

5.7 Shims Under Hole IQIs.

For welds, a shim of material radiographically similar to the weld metal shall be placed between the part and the IQI, if needed, so that the radiographic density throughout the area of interest is no more than minus 15% from (lighter than) the radiographic density through the IQI. The shim dimensions shall exceed the IQI dimensions such that the outline of at least three sides of the IQI image shall be visible in the radiograph.

6. Evaluation

6.1 Quality of Radiographs

All radiographs shall be free from mechanical, chemical, or other blemishes to the extent that they do not mask and are not confused with the image of any discontinuity in the area of interest of the object being radiographed. Such blemishes include, but are not limited to:

1) fogging;

2) processing defects such as streaks, watermarks, or chemical stains;

3) scratches, finger marks, crimps, dirtiness, static marks, smudges, or tears;

4) false indications due to defective screens.

6.2 Radiographic Density

1) Density Limitations

The transmitted film density through the radiographic image of the body of the appropriate hole IQI or adjacent to the designated wire of a wire IQI and the area of interest shall be 1.8 minimum for singe film viewing for radiographs made with an X-ray source and 2.0 minimum for radiographs made with a gamma ray source. For composite viewing of multiple film exposures, each film of the composite set shall have a minimum density of 1.3. The maximum density shall be 4.0 for either single or composite viewing. A tolerance of 0.05 in density is allowed for variations between densitometer readings.

2) Density Variation

(1) General

If the density of the radiograph anywhere through the area of interest varies by more than minus 15% or plus 30% from the density through the body of the hole IQI or adjacent to the designated wire of a wire IQI, within the minimum/maximum allowable density ranges specified in 6.2 1), then an additional IQI shall be used for each

exceptional area or areas and the radiograph retaken. When calculating the allowable variation in density, the calculation may be rounded to the nearest 0.1 within the range specified in 6.2 1).

(2) With Shims

When shims are used with hole type IQIs, the plus 30% density restriction of (1) above may be exceeded, and the minimum density requirements of 6.2 1) do not apply for the IQI, provided the required IQI sensitivity of 6.3 1) is met.

6.3 IQI Sensitivity

1) Required Sensitivity

Radiography shall be performed with a technique of sufficient sensitivity to display the designated hole IQI image and the 2T hole, or the essential wire of a wire IQI. The radiographs shall also display the IQI identifying numbers and letters. If the designated hole IQI image and 2T hole, or essential wire, do not show on any film in a multiple film technique, but do show in composite film viewing, interpretation shall be permitted only by composite film viewing.

2) Equivalent Hole-Type Sensitivity.

A thinner or thicker hold-type IQI than the required IQI may be substituted, provided an equivalent or better IQI sensitivity, as listed in Table 4, is achieved and all other requirements for radiography are met. Equivalent IQI sensitivity is shown in any row of Table 4, which contains the required IQI and hole. Better IQI sensitivity is shown in any row of Table 4, which is above the equivalent sensitivity row. If the required IQI and hole are not represented in the table, the next thinner IQI row from Table 4 may be used to establish equivalent IQI sensitivity.

6.4 Excessive Backscatter

If a light image of the "B," as described in this procedure para. 4.4, appears on a darker background of the radiograph, protection from backscatter is insufficient and the radiograph shall be considered unacceptable. A dark image of the "B," on a lighter background is not cause for rejection.

6.5 Geometric Unsharpness

1) Geometric Unsharpness Determination.

Geometric unsharpness of the radiograph shall be determined in accordance with :

$$\mathbf{Ug = Fd/D}$$

where

Ug = geometric unsharpness

F = source size: the maximum projected dimension of the radiating source (or effective focal spot) in the plane perpendicular to the distance D from the weld or object being radiographed

D = distance from source of radiation to weld or object being radiographed

d = distance from source side of weld or object being radiographed to the film.

D and d shall be measured to the approximate center of the area of interest.

2) Geometric Unsharpness Limitation.

Recommended maximum values for geometric unsharpness are as follows:

Material Thickness, in. (㎜)	Ug Maximum, in. (㎜)
Under 2 (50)	0.020 (0.51)
2 through 3 (50 ~ 75)	0.030 (0.76)
Over 3 through 4 (75 ~ 100)	0.040 (1.02)
Greater than 4 (100)	0.070 (1.78)

Note: Material thickness is the thickness on which the IQI is based.

6.6 Evaluation by Manufacturer

The Manufacturer shall be responsible for the review, interpretation, evaluation, and acceptance of the completed radiographs to assure compliance with the requirements of Article 2 and the referencing Code Section. As an aid to the review and evaluation, the radiographic technique documentation required by section 9 shall be completed prior to the evaluation. The radiograph review form required by section 9 shall be completed during the evaluation. The radiographic technique details and the radiograph review form documentation shall accompany the radiographs. Acceptance shall be completed prior to presentation of the radiographs and accompanying documentation to the Inspector.

7. Acceptance Standards

7.1 ASME Sec. Ⅷ Div.1(UW 51)

Indications shown on the radiographs of welds and characterized as imperfections are unacceptable under the following conditions:

1) any indication characterized as a crack or zone of incomplete fusion or penetration;

2) any other elongated indication on the radiograph which has length greater than:

1) ¼ in.(6mm) for t up ¾ in.(19mm)

2) ⅓t for t from ¾ in.(19mm) to 2¼ in.(57mm)

3) ¾ in.(19mm) for t over 2¼ in.(57mm)

where

t = the thickness of the weld excluding any allowable reinforcement. For a butt weld joining two members having different thicknesses at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in t.

3) any group of aligned indications that have an aggregate length greater than t in a length of 12t, except when the distance between the successive imperfections exceeds 6L where L is the length of the longest imperfection in the group;

4) rounded indications in excess of that specified by the acceptance standards given in Appendix 4 of ASME Sec Ⅷ Div.1.

7.2 ASME Section Ⅷ, Division. 1, UW-52 - (Spot Radiographic Examination)

The acceptability of welds examined by spot radiography shall be judged by the following standards.

1) Welds in which indications are characterized as crack or zones of incomplete fusion or penetration shall be unacceptable.

2) Welds in which indications are characterized as slag inclusions or cavities shall be unacceptable if the length of any such indication is greater than 2/3t where t is the thickness of the weld excluding any allowable reinforcement. For a butt weld joining two members having different thicknesses at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in t. If several indications within the above limitations exist in line, the welds shall be judged acceptable if the sum of the longest dimensions of all such indications is not more than t in a length of 6t (or proportionately for radiographs shorter than 6t) and if the longest indications considered are separated by at least 3L of acceptable weld metal where L is the length of the longest indication. The maximum length of acceptable indications shall be 3/4 in. (19 ㎜). Any such indications shorter than 1/4 in. (6 ㎜) shall be acceptable for any plate thickness.

3) Rounded indications are not a factor in the acceptability of welds not required to be fully radiographed.

7.3 ASME Section Ⅸ, QW-191

Welder and welding operator performance tests by radiography of welds in test assemblies shall be judged unacceptable when the radiograph exhibits any imperfections in excess of the limits specified below.

1) Linear Indications

(1) any type of crack or zone of incomplete fusion or penetration;

(2) any elongated slag inclusion which has a length greater than:

(a) ⅛ in. (3 ㎜) for t up to ⅜ in. (10 ㎜), inclusive

(b) ⅓ t for t over ⅜ (10 ㎜) to 2¼ in. (57 ㎜), inclusive

(c) ¾ in. (19 ㎜) for t over 2¼ in. (57 ㎜)

(3) any group of slag inclusions in line that have an aggregate length greater than t in a length of 12t, except when the distance between the successive imperfections exceeds 6L where L is the length of the longest imperfection in the group.

2) Rounded indications

(1) The maximum permissible dimension for rounded indications shall be 20% of t or ⅛ in. (3 ㎜), whichever is smaller.

(2) For welds in material less than ⅛ in. (3.2 ㎜) in thickness, the maximum number of acceptable rounded indications shall not exceed 12 in a 6 in. (152 ㎜) length of weld. A proportionately fewer number of rounded indications shall be permitted in welds less than 6 in. (152 ㎜) in length.

(3) For welds in material ⅛ in. (3 ㎜) or greater in thickness, the charts in Appendix Ⅱ represent the maximum acceptable types of rounded indications illustrated in typically clustered, assorted, and randomly dispersed configuration. Rounded indications less than 1/32in. (0.8 ㎜) in maximum diameter shall not be considered in the radiographic acceptance tests of welders and welding operators in these ranges of material thicknesses.

7.4 ASME B31.1

Welds that are shown by radiography to have any of the following types of discontinuities are unacceptable:

1) any type of crack or zone of incomplete fusion or penetration;

2) any other elongated indication which has a length greater than:

(1) ¼ in.(6 ㎜) for t up ¾ in.(19 ㎜), inclusive;

(2) ⅓t for t from ¾ in.(19 ㎜) to 2¼ in.(57 ㎜), inclusive.;

(3) ¾ in.(19 ㎜) for t over 2¼ in.(57 ㎜)

where t is the thickness of the thinner portion of the weld.

3) any group of indications in line that have an aggregate length greater than t in a length of 12t, except where the distance between the successive indications exceeds 6L where L is the longest indication in the group;

4) porosity in excess of that shown as acceptable in Appendix Ⅰ of this procedure.

5) root concavity when there is an abrupt change in density, as indicated on the radiograph.

7.5 ASME Section Ⅰ, PW-51

Indications shown on the radiographs of welds and characterized as imperfections are unacceptable under the following conditions:

1) Any indication characterized as a crack or zone of incomplete fusion or penetration;

2) Any other elongated indication on the radiograph that has a length greater than:

(1) ¼ in. (6.0 ㎜) for t up ¾ in. (19 ㎜)

(2) ⅓ t for t from ¾ in. (19 ㎜) to 2¼ in. (57 ㎜)

(3) ¾ in (19 ㎜) for t over 2¼ in (57 ㎜)

where t is the thickness of the weld.

3) Any group of aligned indications that have an aggregate length greater than t in a length of 12t, except when the distance between the successive imperfections exceeds 6L where L is the length of the longest imperfection in the group.

4) Rounded indications in excess of those shown in Appendix 4 of ASME Sec Ⅷ Div.1.

7.6 ASME Section VIII Div.2 paragraph 7.5.3

Indications shown on the radiographs of welds and characterized as imperfections are unacceptable under the following conditions:

a) Linear indications

1) Terminology

Thickness t – the thickness of the weld excluding any allowable reinforcement. For a butt weld joining two member having different thicknesses at the weld, t is the thinner of these If these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the fillet throat shall be included in the calculation of t.

2) Acceptance/Rejection Critera

(a) Any crack of zone of incomplete fusion of lack of penetration

(b) Any other linear indication that has a length greater than:

i) 6mm(1/4in) for t less than or equal to 19mm(3/4in),

ii) t/3 for t greater than 19mm(3/4in) and less than or equal to 57mm(2 1/4in),

iii) 19mm(3/4in) for t greater than 57mm(2 1/4in).

(c) Internal root weld conditions are acceptable when the density or image brightness change as indicated in the radiography is not abrupt. Linear indications on the radiograph at either edge of such conditions shall be evaluated in accordance with the other sections of this paragraph.

b) Rounded indications

1) Terminology

(a) Rounded indications – indications with a maximum length of three times the width or less on the radiograph are defined as rounded indications. These indications may be circular, elliptical, cinical, or irrrgular in shape.

(b) Aligned indications – a sequence of four or more rounded indications shall be considered to be aligned when they touch a line parallel to the length of the weld drawn through the center of the two outer rounded indications.

(c) Thickness t – the thickness of the weld, excluding any allowable reinforcement. For a butt weld joining two members having different thicknesses at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the fillet throat shall be include in the calculation of t.

2) Acceptance criteria

(a) Rounded indication charts – relevant rounded indications characterized as imperfections shall not exceed in accordance with code which ASME SEC Div.2, which illustrate various types of assorted, randomly dispersed and clustered rounded indications for different weld thicknesses greater than 3mm(1/8in). the chart for each thickness range represent full-scale 150mm(6in) radiogreaphs, and shall not be enlatged or reduced. The disrtributions shown are not necessarily the patterns that may appear on the radiograph, but are typical of the concentration and size of indications permitted.

(b) Relevant indications – only those rounded indications that exceed the following dimensions shall be considered relevant and comparaed to the acceptance charts for disposition.

i) t/10 for t less than 3mm(1/8in)

ii) 0.4mm(1/64in) for t greater than or equal to 3mm(1/8in) and less than or equal to 6 mm(1/4in)

iii) 0.8mm(1/32in) for t greater than 6mm(1/4in) and less than or equal to 50mm(2in)

iv) 1.5mm(1/16in) for t greater than 50mm(2in)

v) Maximum size of rounded indication – the maximum permissible size of any indication shall be t/4 or 4mm(5/32in), whichever is smaller; except that an isolated indication separated from an adjacent indication by 25mm(1in) or more may be t/3, or 6mm(1/4in), whichever is less. For t grater than 50mm(2in) the maximum permissible size of an isolated indication shall be increased to 10mm(3/8in).

vi) Aligned rounded indications – aligned rounded indications are acceptable when the summation of the diameters of the indications is less than t in a length of 12t. The length of groups of aligned rounded indications and the spacing between the groups shall meet the requirements.

vii) Clustered indications – the illustrations for clustered indications show up to four times as many indications in a local area, as that shown in the illustrations for random indications. The length of an acceptable cluster shall not exceed the lesser of 25mm(1in) of 2t. Where more than one clustr is present, the sum of the lengths of the clusters shall not exceed 25mm(1in) in a 150mm(6in) length weld.

viii) Weld thicknesss t less than 3mm(1/8in) – for t less than 3mm(1/8in) the maximum number of indications shall not exceed 12in a 150mm(6in) length of weld. A proportionally fewer number of indications shall be permitted in weld. A proportionally fewer number of indications shall be permitted in welds less than 150mm(6in) in length.

(c) Image density – density or image brightness whinin the image of the indication may vary and is not a criterion for acceptance or rejection.

(d) Spacing – the distance between adjacent rounded indicatios is not a factor in determining acceptance or rejection, except as required for isolated indications or groups of aligned indications.

8. Specific Rules

This specific rule contains the radiographic procedural requirements unique to individual codes or standards.

8.1 ASME Sec. Ⅷ Div. 1, UW-35 & Sec. I Pw-35

1) Surface of welds

(1) Butt welds joints shall have complete penetration and full fusion. As-welded surfaces are permitted; however, the surface of welds shall be sufficiently free from coarse ripples, grooves, overlaps, and abrupt ridges and valleys to permit proper interpretation of radiographic and other required nondestructive examinations. If there is a question regarding the surface condition of the weld when interpreting a radiographic film, the film shall be compared to the actual weld surface for determination of acceptability.

(2) A reduction in thickness due to the welding process is acceptable provided all of the following conditions are met.

(a) The reduction in thickness shall not reduce the material of the adjoining surfaces below the minimum required thickness at any point.

(b) The reduction in thickness shall not exceed 1/32 in. (1 ㎜) or 10% of the nominal thickness of the adjoining surface, whichever is less.

(3) Concavity due to the welding process on the root side of a single welded circumferential butt weld is permitted when the resulting thickness of the weld is at least equal to the thickness of the thinner member of the two sections being joined and the contour of the concavity is smooth.

(4) To assure that the weld grooves are completely filled so that the surface of the weld metal at any point does not fall below the surface of the adjoining base material, weld metal may be added as reinforcement on each face of the weld.

The thickness of the weld reinforcement on each face shall not exceed the following;

Material Nominal Thickness, ㎜(in)	Maximum Reinforcement			
	Category B & C Butt Welds		Other Welds	
	㎜	(in)	㎜	(in)
Less than 2.4($^3/_{32}$)	2.4	($^3/_{32}$)	0.8	($^1/_{32}$)
2.4($^3/_{32}$) to 4.8($^3/_{16}$), incl.	3.2	(⅛)	1.6	($^1/_{16}$)
Over 4.8($^3/_{16}$) to 13(½), incl.	4.0	($^5/_{32}$)	2.4	($^3/_{32}$)
Over 13(½) to 25(1), incl.	4.8	($^3/_{16}$)	2.4	($^3/_{32}$)
Over 25(1) to 51(2), incl.	5	(¼)	3.2	($^1/_{8}$)
Over 51(2) to 76(3), incl.	6	(¼)	4	($^5/_{32}$)
Over 76(3) to 102(4), incl.	6	(¼)	6	($^7/_{32}$)
Over 102(4) to 127(5) incl.	6	(¼)	6	($^1/_{4}$)
Over 127(5)	8	($^5/_{16}$)	8	($^5/_{16}$)

8.2 ASME B31.1 , Chapter V

1) Surface of welds. As-welded surfaces are permitted; however, the surface of welds shall be sufficiently free from coarse ripples, grooves, overlaps, abrupt ridges, and valleys to meet the following.

(1) The surface condition of the finished welds shall be suitable for the proper interpretation of radiographic and other nondestructive examinations when nondestructive examinations are required. In those cases where there is a question regarding the surface condition on the interpretation of a radiographic

film, the film shall be compared to the actual weld surface for interpretation and determination of acceptability.

(2) Undercut shall not exceed 1/32 in. (1.0 ㎜) and shall not encroach on the minimum required section thickness.

(3) If the surface of the weld requires grinding to meet the above criteria, care shall be taken to avoid reducing the weld or base material below the minimum required thickness.

(4) Concavity on the root side of a single welded circumferential butt weld is permitted when the resulting thickness of the weld is at least equal to the thickness of the thinner member of the two sections being joined and the contour of the concavity is smooth without sharp edges. The internal condition of the root surface of a girth weld, which has been examined by radiography, is acceptable only when there is a gradual change in the density, as indicated in the radiograph. If a girth weld is not designated to be examined by radiography, a visual examination may be performed at welds which are readily accessible.

2) Reinforcement of welds

The weld reinforcement allowed on girth and longitudinal butt welds shall be as tabulated in below.

Thickness of base metal in.(㎜)	Maximum Thickness of Reinforcement for Design Temperature					
	> 400 ℃		175 ~ 400 ℃		< 175 ℃	
	in.	㎜	in.	㎜	in.	㎜
Up to 1/8(3.0), incl.	1/16	2.0	3/32	2.5	3/16	5.0
Over 1/8(3.0) to 3/16(5.0), incl.	1/16	2.0	1/8	3.0	3/16	5.0
Over 3/16(5.0) to 1/2(13.0), incl.	1/16	2.0	5/32	4.0	3/16	5.0
Over 1/2(13.0) to 1(25.0), incl.	3/32	2.5	3/16	5.0	3/16	5.0
Over 1(25.0) to 2(50.0), incl.	1/8	3.0	1/4	6.0	1/4	6.0
Over 2(50.0)	5/32	4.0	The greater of 1/4 in(6 ㎜). or 1/8 times the width of the weld in inches(millimeters).			

9.0 Repairing

All unacceptable indications shall be repaired and re-examined at least with the same technique. All the radiographs relating to repairing areas shall be identified by placing a lead letter “R” and shall be re-evaluated in compliance with original acceptance criteria.

Subsequent repairs shall be identified by R1, R2, etc…

10. Documentation

10.1 SGT shall prepare and document the radiographic technique details and a radiograph review form. Each radiograph shall be documented on the radiographic examination report. As a minimum, the report shall include required information, described in Article 2. T-291, ASME Section V. The report shall be prepared and dated by the qualified and certified Level Ⅱ who examined the evaluation and disposition of the radiographs and approved by the qualified and certified Level Ⅱ or Level Ⅲ who performed the final acceptance of the radiographs.

10.1.1 T-291, Article2, ASME Section V

1) identification
2) number of radiographs(exposure)
3) X-ray voltage or isotope type used
4) source size
5) base material type and thickness, weld thickness, weld reinforcement thickness
6) source-to-object distance
7) distance from source side of object to film
8) film manufacturer and Manufacturer's type
9) number of film in each film holder/cassette
10) single- or double-wall exposure
11) single- or double-wall wiewing

10.2 A report shall be prepared and furnished to the client. Report of Radiographic Examination (Appendix-Ⅲ) will be used unless otherwise specified by client.

11. Appendix

Report of Radiographic Examination - 2 sheets

Table 1. Hole Type IQI Designation, Thickness, and Hole Diameters

IQI Designation, in. (㎜)	IQI Thickness, in. (㎜)	1T Hole Diameter, in. (㎜)	2T Hole Diameter, in. (㎜)	4T Hole Diameter, in. (㎜)
5	0.005(0.13)	0.010(0.25)	0.020(0.51)	0.040(1.02)
7	0.0075(0.19)	0.010(0.25)	0.020(0.51)	0.040(1.02)
10	0.010(0.25)	0.010(0.25)	0.020(0.51)	0.040(1.02)
12	0.0125(0.32)	0.0125(0.32)	0.025(0.64)	0.050(1.27)
15	0.015(0.38)	0.015(0.38)	0.030(0.76)	0.060(1.52)
17	0.0175(0.44)	0.0175(0.44)	0.035(0.89)	0.070(1.78)
20	0.020(0.51)	0.020(0.51)	0.040(1.02)	0.080(2.03)
25	0.025(0.64)	0.025(0.64)	0.050(1.27)	0.100(2.54)
30	0.030(0.76)	0.030(0.76)	0.060(1.52)	0.120(3.05)
35	0.035(0.89)	0.035(0.89)	0.070(1.78)	0.140(3.56)
40	0.040(1.02)	0.040(1.02)	0.080(2.03)	0.160(4.06)
45	0.045(1.14)	0.045(1.14)	0.090(2.29)	0.180(4.57)
50	0.050(1.27)	0.050(1.27)	0.100(2.54)	0.200(5.08)
60	0.060(1.52)	0.060(1.52)	0.120(3.05)	0.240(6.10)
70	0.070(1.78)	0.070(1.78)	0.140(3.56)	0.280(7.11)
80	0.080(2.03)	0.080(2.03)	0.160(4.06)	0.320(8.13)
100	0.100(2.54)	0.100(2.54)	0.200(5.08)	0.400(10.16)
120	0.120(3.05)	0.120(3.05)	0.240(6.10)	0.480(12.19)
140	0.140(3.56)	0.140(3.56)	0.280(7.11)	0.560(14.22)
160	0.160(4.06)	0.160(4.06)	0.320(8.13)	0.640(16.26)
200	0.200(5.08)	0.200(5.08)	0.400(10.16)	…
240	0.240(6.10)	0.240(6.10)	0.480(12.19)	…
280	0.280(7.11)	0.280(7.11)	0.560(14.22)	…

Table 2. Wire IQI Designation, Wire Diameter and Wire Identity

Set A			Set B		
Wire Diameter, in.	(mm)	Wire Identity	Wire Diameter, in.	(mm)	Wire Identity
0.0032	(0.08)	1	0.010	(0.25)	6
0.004	(0.01)	2	0.013	(0.33)	7
0.005	(0.13)	3	0.016	(0.41)	8
0.0063	(0.16)	4	0.020	(0.51)	9
0.008	(0.20)	5	0.025	(0.64)	10
0.010	(0.25)	6	0.032	(0.81)	11

Set C			Set D		
Wire Diameter, in.	(mm)	Wire Identity	Wire Diameter, in.	(mm)	Wire Identity
0.032	(0.81)	11	0.100	(2.54)	16
0.040	(1.02)	12	0.126	(3.20)	17
0.050	(1.27)	13	0.160	(4.06)	18
0.063	(1.60)	14	0.200	(5.08)	19
0.080	(2.03)	15	0.250	(6.35)	20
0.100	(2.54)	16	0.320	(8.13)	21

Table 3. IQI Selection

Nominal Single-Wall Material Thickness Range		IQI			
		Source Side		Film Side	
in.	mm	Hole Type Designation	Wire-Type Essential Wire	Hole Type Designation	Wire-Type Essential Wire
Up to 0.25 incl.	Up to 6.4 incl.	12	5	10	4
Over 0.25 through 0.375	Over 6.4 through 9.5	15	6	12	5
Over 0.375 through 0.50	Over 9.5 through 12.7	17	7	15	6
Over 0.50 through 0.75	Over 12.7 through 19.0	20	8	17	7
Over 0.75 through 1.00	Over 19.0 through 25.4	25	9	20	8
Over 1.00 through 1.50	Over 25.4 through 38.1	30	10	25	9
Over 1.50 through 2.00	Over 38.1 through 50.8	35	11	30	10
Over 2.00 through 2.50	Over 50.8 through 63.5	40	12	35	11
Over 2.50 through 4.00	Over 63.5 through 101.6	50	13	40	12
Over 4.00 through 6.00	Over 101.6 through 152.4	60	14	50	13
Over 6.00 through 8.00	Over 152.4 through 203.2	80	16	60	14
Over 8.00 through 10.00	Over 203.2 through 254.0	100	17	80	16
Over 10.00 through 12.00	Over 254.0 through 304.8	120	18	100	17
Over 12.00 through 16.00	Over 304.8 through 406.4	160	20	120	18
Over 16.00 through 20.00	Over 406.4 through 508.0	200	21	160	20

Table 4. Equipvalent Hole-Type IQI Sensitivity

Hole-Type Designation 2T Hole	Equivalent Hole-Type Designation	
	1T Hole	4T Hole
10	15	5
12	17	7
15	20	10
17	25	12
20	30	15
25	35	17
30	40	20
35	50	25
40	60	30
50	70	35
60	80	40
80	120	60
100	140	70
120	160	80
160	240	120
200	280	140

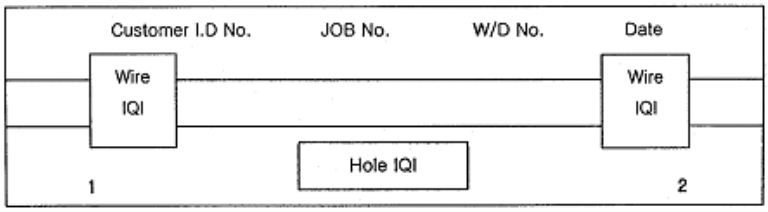
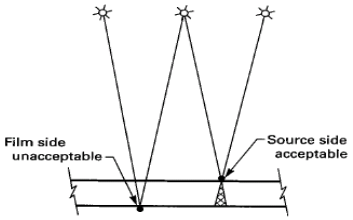
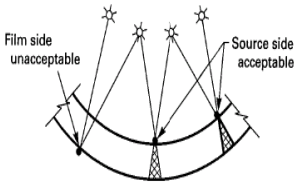


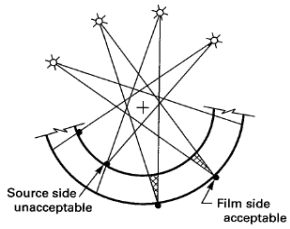
Fig 1. Identification System



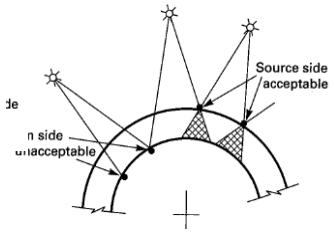
(a) Flat components or longitudinal Seam [see 5.3 1) (1) (a)] (see sketch (e) for alternate)



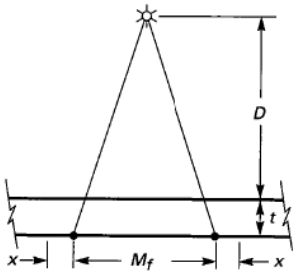
(b) Curved components with radiation source to film distance less than radius of component [see 5.3 1) (1) (b)]



c) Curved components with convex surface towards radiation source [see 5.3 1) (1) (c)]



(d) Curved components with radiation source to film distance greater than radius of curvature [see 5.3 1) (2) (a]



(e) Source side marker alternate flat component or longitudinal seam

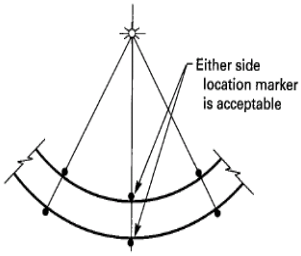
x = (t/D) (Mf/2)

x = additional required coverage, in. beyond film side location marker

t = component thickness, in

M_f = film side location marker interval, in.

D = source to component distance, in. [see 5.3 1) (2) (b)]



(f) Curved components with radiation source at center curvature [see 5.3 1) (3)]

* LEGEND ; Radiation source- *

Location marker - °

Component center- +

Fig 2. Location Marker Sketches

Appendix

Report of Radiographic Examination - A

방 사 선 투 과 검 사 보 고 서
REPORT OF RADIOGRAPHIC EXAMINATION

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Report No. 보고서번호	
Page No. 페이지번호	

Project Name 공사명	Owner / Customer 주문주/고객	Job No. 공사번호
Item Name / 제품명	Item No / 제품 번호	Drawing No. 도면번호 Rev No.
Material/Thickness(Reinforcement) 재질/두께(여성부)	Num. Of film cas. 카세트 당 필름매수	Radiation Source 방사선원
☐ mm ☐ in.	☐ one sheet per cassette ☐ two sheets per cassette	☐ X-ray ☐ Ir-192 ☐ Co-60
Film Size 필름크기	Development Condition 현상조건	Source / Size 선원크기
☐ 3 1/3 X 12 ☐ mm ☐ 4 1/2 X 12 ☐ in.		
Film Mfr./Type 필림제조사/종류	IQI 투과도계종류 ID 번호	Exposure 노출
	☐ ASME ☐ KS(JIS)	

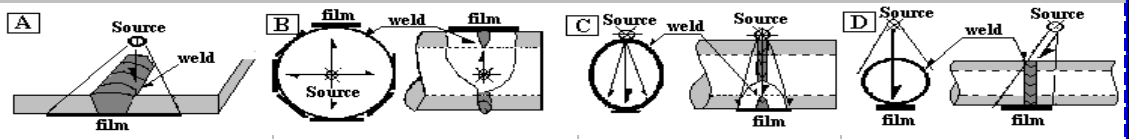
Sereem 증감지 Thickness 두께	IQI Placement 투과도계위치	Min. SOD	Max. OFD
0.005 ☐ mm ☐납Lead ☐형광Fluorescent ☐ in.	☐ Film Side ☐ Source Side	mm	mm

Density		Sensitivity		No.of Exposure		Total Sheet		sheet's

Acceptance Standard & Applicable procedures / 합격기준 및 적용절차서	Step

Defect Code 결함약호	NAD - 완전함 No Apparent Defect	S . D - 표면 결함 Surface Defect	T . I - 텅스텐 불순물 Tungsten Inclusion
	R.U.C - 루트 언더컷 Root Under Cut	R . C - 루트 요면 Root Concavity	I . P - 용입 불량 Incomplete Penetration
	U . C - 표면 언더컷 Under Cut	C . K - 균열 Crack	I . N - 불순물 Inclusion(slag)
	S.P.T - 표면 패임 Surface Pitting	G . P - 기포Gas Pore(Blow Hole)	L . F - 융합 불량 Lack of Fusion
	E . P - 과 침투 Excessive Penetration		N.S.D - 양호함 Non Significant Defect

Exposure Set-up 촬영배치 : ( )



SWSV SWSV DWSV DWDV

필름확인번호 Film Identification No.	합격 Accept	불합격 Reject	등급 Grade	판독 Interpretation	용접사 번호 Welder No.	비고 Remarks

NDT.Co	Reviewed QC	Approved.By Level III	Reviewed by Client	Reviewed by AI
Operator sign Level II	Interpreter sign Level II			

Report of Radiographic Examination - B

방 사 선 투 과 검 사 보 고 서

REPORT OF RADIOGRAPHIC EXAMINATION

SUNG JIN GEOTEC CO., LTD		Report 보고서번호	
#20-1,SUNG AM-DONG,NAM-KU,ULSAN,KOREA TEL:(052)228-5801~4,FAX(052)228-5989		Page No. 페이지번호	

필 름 확 인 번 호 Film Identification No.					합 격 Accept	불합격 Reject	등 급 Grade	판 독 Interpretation	용접사 번호 Welder No.	비 고 Remarks

Ⅱ. Ultrasonic Examination Procedure

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1. Scope

1.1 This procedure describes the minimum requirements for methods and techniques to be used when performing straight beam or angle beam, pulse-echo ultrasonic examination of welds in accordance with the requirements of Article 4, ASME Section V.

1.2 This procedure describes the general requirements for safety, materials, equipment, personnel, technique and acceptance criteria. When differences exist between this procedure and technical specification, the technical specification shall govern.

1.3 The weld and/or material types and configuration to be examined shall be in accordance with manufacturing drawing.

1.4 This procedure shall not be used to perform UT in lieu of RT.

2. References

2.1 ASME Sec. Ⅰ Power Boilers (2007 Edition-2009ADD)

2.2 ASME Sec. V Nondestructive Examination (2007 Edition-2009ADD)

2.3 ASME Sec. Ⅷ Div.1&Div.2 Rules for construction of Pressure Vessels (2007 Edition-2009ADD)

2.4 ASME B31.1 Power Piping (2007 Edition-2009ADD)

2.5 ASME Sec. Ⅸ Welding and Brazing Qualification (2007 Edition-2009ADD)

2.6 ASNT Recommended Practice No. SNT-TC-1A for NDT Personnel Qualification and Certification (2006 Ed.)

3. General Requirements

3.1 Procedure Qualification.

This procedure shall be qualified before use according to the table 1, using the form "Procedure Qualification for Essential/Nonessential variable".

3.2 Personnel Qualification.

1) Personnel shall be qualified and certified in accordance with the employer written practice that shall meet SNT-TC-1A.

2) Only qualified and certified Level Ⅱ or Level Ⅲ Personnel shall make determinations to the acceptability of examination results.

3.3 Procedure Requirement

1) Ultrasonic examination shall be performed in accordance with a written procedure which shall as a minimum, contain the requirements listed in Table 1. The written procedure shall establish a single value, or range of values, for each requirement. If required any additional

written procedures will need to be submitted to the Purchaser's inspector for review prior to use.

2) When procedure qualification is specified, a change of requirement in Table 1. identified as an essential variable from the specified value, or range of values, shall require requalification of the written procedure. A change of a requirement identified as a nonessential variable from the specified value, or range of values, does not require requalification of the written procedure. All changes of essential or nonessential variables from the value, or range of values, specified by the written procedure shall require revision of, or an addendum to, the written procedure.

3.4 The application of this procedure is limited to straight beam and angle beam method of ultrasonically examining the welded joints, heat affected zone and adjacent base material for at least ½ in.(13 ㎜) on each side of the weld, using manual, contact and pulse-echo ultrasonic techniques.

3.5 Examination shall be conducted at the time specified on the related applicable drawings prepared including weld configuration(sing & double groove joint, tee joint, ect - See Fig. 6) thickness dimension and base material product form(pipe, plate, ect) from in accordance with the referencing Code section or manufacturing drawing.

3.6 The extent of examination will be designated by the customer or his representative.

3.7 Surface condition from which the examination

1) The finished contact surfaces shall be free from weld spatter, paint, and any roughness that would interfere with free movement of the search unit or impair the transmission of ultrasound.

2) The weld surface shall be finished so that they cannot mask or be confused with reflections from defects, and shall merge smoothly onto the surface of the adjacent base materials.

3.8 Specification Requrirements

1) General Requirements

(a) All welds greater than 50 mm in thickness shall be ultrasonically examined in addition to radiographic examination detailed above. This requirement applies to welds jointing shells greater than 50 mm in thickness to heads with a thickness less than 50 mm. For acceptance, such examinations shall be made after final PWHT.

4. Equipment

4.1 Instrument Requirements

A pulse-echo-type of and manually operated ultrasonic instrument shall be used. The instrument shall be capable of operation at frequencies over the range of at least 1 MHz to 5 MHz and shall be equipped with a stepped gain control in units of 2.0 dB or less. If the instrument has a damping control, it may be used if it does not reduce the sensitivity of the examination. The reject control shall be in the “off” position for all examinations, unless it can be demonstrated that it does not affect the linearity of the examination. The following instruments or instruments or equivalent shall be used.

Instrument Type	Model	Maker
Manual Pulse-Echo (A-scope)	USK EPOCH SITESCAN	Krautkramer Panametrics Sonatest

4.2 Search Units

1) General

The nominal frequency shall be from 1 MHz to 5 MHz unless variables, such as production material grain structure, require the use of other frequencies to assure adequate penetration or better resolution. Search units with contoured contact wedges may be used to aid ultrasonic coupling. The search unit angle and size used for examination shall be selected according to the following table.

Type	Angle	Search Unit Size(㎜)	shape
Straight beam	0°	φ10, φ24	Round
Angle beam	45°, 60°, 70°	8×9,14×14,20×22	Rectangular

Kind of Search Unit

Type	Angle(°)	Frequency(㎒)	Element Size(㎜)
MWB-45	45	2,4	8×9
MWB-60	60	2,4	8×9
MWB-70	70	2,4	8×9
2C14*14A45	45	2	14×14
2C14*14A60	60	2	14×14
2C20*22A45	45	2	20×22
2C20*22A60	60	2	20×22
2C8*14LAD45	45	2	8×14 or 10×18
2C8*14LAD60	60	2	8×14 or 10×18

2C8*14LAD70	70	2	8×14 or 10×18
MB4S	0	4	10
B2S	0	2	24

2) Cladding-Search Units for Technique One

Dual elements search units using an angled pitch-catch technique shall be used. The included angle between the beam paths shall be such that the effective focal spot of the search unit is centered in the area of interest.

3) Angle and mode of wave propagation in the material

(1) Normal incident longitudinal wave beams for what are generally termed straight beam examinations or

(2) Angle beam longitudinal waves, where both refracted longitudinal and shear waves are present in the material under examination. When used for thickness measurement or clad examination, these examinations are generally considered to be straight beam examinations. When used for weld examinations, they are generally termed angle beam examinations or

(3) angle beam shear waves, where incident angles in wedges produce only refracted shear waves in the material under examination are generally termed angle beam examinations.

4.3 Couplant

1) General

The couplant, including additives, shall not be detrimental to the material being examined.

2) Control of Contaminants

(1) Couplants used on nickel base alloys shall not contain more than 250 ppm of sulfur.

(2) Couplants used on austenitic stainless steel or titanium shall not contain more than 250 ppm of halides (chlorides plus fluorides).

4.4 Calibration Blocks

1) Reflectors

Known reflectors (i.e., side drilled holes, flat bottom holes, notches, etc.) shall be used to establish primary reference responses of the equipment.

2) Material

(1) Similar Metal welds

The material from which the block is fabricated shall be of the same product form and material specification or equivalent P-Number grouping as one of the materials being examined. For the purposes of this paragraph, P-No. 1, 3, 4 and 5 materials are considered equivalent.

(2) Dissimilar Metal welds

The material selection shall be based on the material on the side of the weld from which the examination will be conducted. If the examination will be conducted from both sides, calibration reflectors shall be provided in the both materials.

3) Quality

Prior to fabrication, the block material shall be completely examined with a straight beam search unit. Areas that contain an indication exceeding the remaining back-wall reflection shall be excluded from the beam paths required to reach the various calibration reflectors.

4) Cladding

When the component material is clad, the block shall be clad by the same welding procedure as the production part. It is desirable to have component materials which have been clad before the drop outs or prolongations are removed. When the cladding is deposited using an automatic welding process, and, if due to block size, the automatic welding process is impractical, deposition of clad may be by the manual method.

5) Heat Treatment

The calibration block shall receive at least the minimum tempering treatment required by the material specification for the type and grade. If the calibration block contains welds other than cladding, and the component weld at the time of the examination has been heat treated, the block shall receive the same heat treatment.

6) Surface Finish

The finish on the scanning surfaces of the block shall be representative of the scanning surface finishes on the component to be examined.

7) Block Curvature (Except for Piping)

(1) Materials With Diameters Greater Than 20 in. (500 ㎜)

For examinations in materials where the examination surface diameter is greater than 20 in. (500 ㎜), a block of essentially the same curvature, or alternatively, a flat basic calibration block, may be used.

(2) Materials With Diameters 20 in. (500 ㎜) and less

For examinations in materials where the examination surface diameter is equal to or less than 20 in. (500 ㎜), a curved block shall be used. Except where otherwise stated in this Article, a single curved basic calibration block may be used for examinations in the range of curvature from 0.9 to 1.5 times the basic calibration block diameter. For example, an 8 in. (200 ㎜) diameter block may be used to calibrate for examinations on surfaces in the range of curvature from 7.2 in. to 12in. (180 ㎜ to 300 ㎜) in diameter.

The curvature range from 0.94 in. to 20 in. (24 ㎜ to 500 ㎜) in diameter requires 6 curved blocks as shown in Fig. 1 for any thickness range.

(3) Alternative for Convex Surface

As an alternative to the requirements in 7) (1) when examining from the convex surface by the straight beam contact technique, Appendix G of Article 4, Section V may be used.

8) Non-Piping Calibration Blocks

(1) Basic Calibration Block

The basic calibration block configuration and reflectors shall be as shown in Fig 2. The block size and reflector locations shall be adequate to perform calibrations for the beam angles used.

(2) Block Thickness

The block thickness (T) shall be per Fig. 2.

(3) Block Range of Use

When the block thickness ±1 in. (25 ㎜) spans two weld thickness ranges as shown in Fig 2, the block's use shall be acceptable in those portions of each thickness range covered by 1 in. (25 ㎜) of the calibration block's thickness.

9) Piping Calibration Blocks

The basic calibration block configuration and reflectors shall be as shown in Fig 3. The basic calibration block shall be a section of pipe of the same nominal size and schedule. The block size and reflector locations shall be adequate to perform calibration for the beam angles used.

10) Cladding Calibration Blocks

(1) Calibration Rock for Technique One

The basic calibration block configuration and reflectors shall be as shown in Fig. 4. Either a side-drilled hole or a flat bottom hole may be used. The thickness of the weld overlay shall be at least as thick as that to be examined. The thickness of the base material shall be at least twice the thickness of the cladding.

(2) Calibration Block for Technique Two

The basic calibration block configuration and reflectors shall be as shown in Fig. 5. A flat bottom hole drilled to the weld metal overlay interface shall be used. This hole may be drilled from the base material or weld overlay side. The thickness of the weld overlay shall be at least as thick as that to be examined. The thickness of the base material shall be within 1 in. (25) of the calibration block thickness when the examination is performed from the base material surface. The thickness of the base material on the calibration block shall be at least twice the thickness of the cladding when the examination is performed from the clad surface.

5. Miscellaneous Requirements

5.1 Identification of Weld Examination Areas

1) Weld Locations

Weld locations and their identification shall be recorded on a weld map or in an identification plan.

2) Marking

If welds are to be permanently marked, low stress stamps and/or vibratooling may be used. Markings applied after final stress relief of the component shall not be any deeper than 3/64 in. (1.2).

3) Reference System

Each weld shall be located and identified by a system of reference points. The system shall permit identification of each weld center line and designation of regular intervals along the length of the weld. A general system for layout of vessel welds is described in Nonmandatory Appendix A; however, a different system may be utilized provided it meets the above requirements.

6. Calibration

6.1 Instrument Linearity Checks

The requirements of 6.1 1) and 6.1 2) shall be met at intervals not to exceed three months or prior to first use thereafter.

1) Screen Height Linearity

The ultrasonic instrument's screen height linearity shall be evaluated in accordance with Mandatory Appendix Ⅰ.

2) Amplitude Control Linearity

The ultrasonic instrument's amplitude control linearity shall be evaluated in accordance with Mandatory Appendix Ⅱ.

6.2 General Calibration Requirements

1) Ultrasonic System

Calibrations shall include the complete ultrasonic system and shall be performed prior to use of the system in the thickness range under examination.

2) Calibration Surface

Calibrations shall be performed from the surface (clad or unclad; convex or concave) corresponding to the surface of the component from which the examination will be performed.

3) Couplant

The same couplant to be used during the examination shall be used for calibration.

4) Contact Wedges

The same contact wedges to be used during the examination shall be used for calibration.

5) Instrument Controls

Any control which affects instrument linearity (e.g., filters, reject, or clipping) shall be in the same position for calibration, calibration checks, instrument linearity checks, and examination.

6) Temperature

For contact examination, the temperature differential between the calibration block and examination surfaces shall be within 25 °F (14℃).

6.3 Calibration for Non-Piping

1) System Calibration for Distance Amplitude Techniques

(1) Calibration Block(s)

Calibrations shall be performed utilizing the calibration block shown in Fig. 2.

(2) Techniques

Mandatory Appendices Ⅰ and Ⅱ provide general techniques for straight beam and angle beam as required by ASME, Art.4 T 461.1 and T 461.2.

(3) Angle Beam Calibration

As applicable, the calibration shall provided the following measurements:

(a) distance range calibration;

(b) distance-amplitude ;

(c) echo amplitude measurement from the surface notch in the basic calibration block. When an electronic distance-amplitude correction device is used, the primary reference responses from the basic calibration block shall be equalized over the distance range to be employed in the examination. The response equalization line shall be at a screen height of 40% to 80% of full screen height.

(4) Straight Beam Calibration.

The calibration shall provide the following measurements:

(a) distance range calibration, and;

(b) distance-amplitude correction in the area of interest.

When an electronic distance-amplitude correction device is used, the primary reference responses from the basic calibration block shall be equalized over the distance range to be employed in the examination. The response equalization line shall be at a screen height of 40% to 80% of full screen height.

2) Calibration technique of angle beam (DAC)

(1) 1⁄4*T* SDH Indication. Position the search unit for maximum response from the 1⁄4*T* SDH. Place one end of the indexing strip against the front of the search unit, the other end extending in the direction of the beam. Mark the number 2 on the indexing strip at the scribe line which is directly above the SDH. (If the search unit covers the scribe line, the marks may be made on the side of the search unit.)

(2) 1⁄2*T* and 3⁄4*T* SDH Indications. Position the search unit for maximum indications from the 1⁄2*T* and 3⁄4*T* SDHs. Keep the same end of the indexing strip against the front of the search unit. Mark the numbers 4 and 6 on the indexing strip at the scribe line, which are directly above the SDHs.

(3) 5⁄4T SDH Indication. If possible, position the search unit so that the beam bounces from the opposite surface to the 3⁄4*T* SDH. Mark the number 10 on the indexing strip at the scribe line, which is directly above the SDH.

(4) Notch Indication. Position the search unit for the maximum opposite surface notch indication. Mark the number 8 on the indexing strip at the scribe line, which is directly above the notch.

(5)Index Numbers. The numbers on the indexing strip indicate the position directly over the reflector in sixteenths of the V-path.

(6) Depth. The depth from the examination surface to the reflector is *T* at 8, 3⁄4*T* at 6 and 10, 1⁄2*T* at 4, 1⁄4*T* at 2, and 0 at 0. Interpolation is possible for smaller increments of depth. The position marks on the indexing strip may be corrected for the radius of the hole if the radius is considered significant to the accuracy of reflector's location.

3) Calibration thehnique of straight beam (DAC)

(1) Delay Control Adjustment. Position the search unit for the maximum first indication from the 1⁄4*T* SDH. Adjust the left edge of this indication to line 2 on the screen with the delay control.

(2) Range Control Adjustment. Position the search unit for the maximum indication from 3⁄4*T* SDH. Adjust the left edge of this indication to line 6 on the screen with the range control.

(3) Repeat Adjustments. Repeat the delay and range control adjustments until the 1⁄4*T* and 3⁄4*T* SDH indications start at sweep lines 2 and 6.

(4) C-461.4 Back Surface Indication. The back surface indication will appear near sweep line 8.

(5) C-461.5 Sweep Readings. Two divisions on the sweep equal *1⁄4T*.

6.4 Calibration for Piping

1) System Calibration for Distance Amplitude Techniques

(1) Calibration block(s)

Calibrations shall be performed utilizing the calibration block shown in Fig. 3.

(2) Angle Beam Calibration

The angle beam shall be directed toward the calibration reflector that yields the maximum response. The gain control shall be set so that this response is 80% ±5% of full screen height. This shall be the primary reference level. The search unit shall then be manipulated, without changing instrument settings, to obtain the maximum responses from the calibration reflectors at the distance increments necessary to generate a three-point distance-amplitude correction (DAC) curve. Separate calibrations shall be established for both the axial and circumferential notches. These calibrations shall establish both the distance range calibration and the distance amplitude correction.

(3) Alternate Calibration Reflectors

Side-drilled holes may be Used provided that it can be demonstrated that the hole calibration produces a sensitivity equal to or greater than the notch calibration.

(4) Straight Beam Calibration

When required, straight beam calibrations shall be performed to the requirements of Nonmandatory Appendix C using the side drilled hole alternate calibration reflector of 6.4 1) (3). This calibration shall establish both the distance range calibration and the distance amplitude correction.

2) System Calibration for Non-Distance Amplitude Techniques

Calibration includes all those actions required to assure that the sensitivity and accuracy of the signal amplitude and time outputs of the examination system(whether displayed, recorded, or automatically processed) are repeated from examination to examination. Calibration may be by use of basic calibration blocks with artificial or discontinuity reflectors. Methods are provided in Nonmandatory Appendices B and C. Other methods of calibration may include sensitivity adjustment based on the examination material, etc.

6.5 Calibration for Cladding

1) Calibration for Technique One

Calibrations shall be performed utilizing the calibration block shown in Fig. 4. The search unit shall be positioned for the maximum response from the calibration reflector. The gain

control shall be set so that this response is 80% ±5% of full screen height. This shall be the primary reference level.

2) Calibration for Technique Two

Calibrations shall be performed utilizing the calibration block shown in Fig. 5. The search unit shall be positioned for the maximum response of the first resolvable indication from the bottom of the calibration reflector. The gain shall be set so that this response is 80% ±5% of full screen height. This shall be the primary reference level.

6.6 Calibration Confirmation

1) System Changes

When any part of the examination system is changed, a calibration check shall be made on the basic calibration block to verify that distance range points and sensitivity setting(s) satisfy the requirements of 6.6 3).

2) Periodic Examination Checks

A calibration check on at least one of the basic reflectors in the basic calibration block or a check using a simulator shall be made at the finish of each examination or series of similar examinations, every 4 hr during the examination, and when examination personnel (except for automated equipment) are changed. The distance range points and sensitivity setting(s) recorded shall satisfy the requirements of 6.6 3).

(1) Simulator Checks

Any simulator checks that are used shall be correlated with the original calibration on the basic calibration block during the original calibration. The simulator checks may use different types of calibration reflectors or blocks (such as IIW) and/or electronic simulation. However the simulation used shall be identifiable on the calibration sheet(s). The simulator check shall be made on the entire examination system. The entire system does not have to be checked in one operation; however, for its check, the search unit shall be connected to the ultrasonic instrument and checked against a calibration reflector. Accuracy of the simulator checks shall be confirmed, using the basic calibration block at the conclusion of each period of extended use, or every three months, whichever is less.

3) Confirmation Acceptance Values

(1) Distance Range Points

If any distance range point has moved on the sweep line by more than 10% of the distance reading or 5% of full sweep, whichever is greater, correct the distance range calibration and note the correction in the examination record. All recorded indications

since the last valid calibration or calibration check shall be reexamined and their values shall be changed on the data sheets or re-recorded.

(2) Sensitivity Settings

If any sensitivity setting has changed by more than 20% or 2dB of its amplitude, correct the sensitivity calibration and note the correction in the examination record. If the sensitivity setting has decreased, all data sheets since the last valid calibration check shall be marked void and the area covered by the voided data shall be reexamined. If the sensitivity setting has increased, all recorded indications since the last valid calibration or calibration check shall be reexamined and their values shall be charged on the data sheets or re-recorded.

7. Examination

7.1 General Examination Requirements

1) Examination Coverage

The volume to be scanned shall be examined by moving the search unit over the scanning surface so as to scan the entire examination volume for each required search unit.

(1) Each pass of the search unit shall overlap a minimum of 10% of the transducer (piezoelectric element) dimension parallel to the direction of scan indexing. As an alternative, if the sound beam dimension parallel to the direction of scan indexing is measured in accordance with ASME Sec. Ⅴ Art. 6 Nonmandatory Appendix B, B-466, Beam Spread measurement rules, each pass of the search unit may provide overlap of the minimum beam dimension determined.

(2) Oscillation of the search unit is permitted if it can be demonstrated that overlapping coverage is provided.

2) Pulse Repetition Rate

The pulse repetition rate shall be small enough to assure that a signal from a reflector located at the maximum distance in the examination volume will arrive back at the search unit before the next pulse is placed on the transducer.

3) Rate of Search Unit Movement.

The rate of search unit movement (scanning speed) shall not exceed 6in./s (152 ㎜/s), unless:

(1) the ultrasonic instrument pulse repetition rate is sufficient to pulse the search unit at least six times within the time necessary to move one-half the transducer

(piezoelectric element) dimension parallel to the direction of the scan at maximum scanning speed; or,

(2) a dynamic calibration is performed on multiple reflectors, which are within ±2dB of a static calibration and the pulse repetition rate meets the requirements of 7.1 2).

4) Scanning Sensitivity Level

(1) Distance Amplitude Techniques

The scanning sensitivity level shall be set a minimum of 6dB higher than the reference level gain setting.

(2) Non-Distance Amplitude Techniques

The level of gain used for scanning shall be appropriate for the configuration being examined and shall be capable of detecting the calibration reflectors at the maximum scanning speed.

5) Surface Preparation

When the base material or weld surface interferes with the examination, the base material or weld shall be prepared as needed to permit the examination. The contact surfaces shall be free from weld spatter roughness, or other conditions that interfere with free movement of the search unit or impair the transmission of ultrasound.

7.2 Weld Joint Distance Amplitude Technique

When the referencing Code Section specifies a distance amplitude technique, weld joints shall be scanned with an angle beam search unit in both parallel and transverse directions (4 scans) to the weld axis. Before performing the angle beam examinations, a straight beam examination shall be performed on the volume of base material through which the angle beams will travel to locate any reflectors that can limit the ability of the angle beam to examine the weld volume.

1) Angle Beam Technique

(1) Beam Angle

The search unit and beam angle selected shall be appropriate for the configuration being examined and shall be capable of detecting the calibration reflectors, over the required angle beam path.

(2) Reflectors Parallel to the Weld Seam

The angle beam shall be directed at approximate right angles to the weld axis from both sides of the weld (i.e., from two directions) on the same surface when possible. The search unit shall be manipulated so that the ultrasonic energy passes through the required volume of weld and adjacent base material.

(3) Reflectors Transverse to the Weld Seam

The angle beam shall be directed essentially parallel to the weld axis. The search unit shall be manipulated so that the ultrasonic energy passes through the required volume of weld and adjacent base material. The search unit shall be rotated 180 deg and the examination repeated. If the weld cap is not machined or ground flat, the examination shall be performed from the base metal on both sides of the weld cap in both weld axis directions.

2) Restricted Access Welds

Welds that cannot be fully examined from two directions using the angle beam technique (e.g., corner and tee joints) shall also be examined, if possible, with a straight beam technique. These areas of restricted access shall be noted in the examination report.

3) Inaccessible Welds

Welds that cannot be examined from at least one side (edge) using the angle beam technique shall be noted in the examination report. For flange welds, the weld may be examined with a straight beam or low angle longitudinal waves from the flange face provided the examination volume can be covered.

7.3 Cladding Techniques

The techniques described in these paragraphs shall be used when examinations of weld metal overlay cladding are required by a referencing Code Section. When examination for lack of bond and clad flaw indications is required, Technique one shall be used. When examination for lack of bond only is required, Technique Two may be used.

1) Technique One

The examination shall be performed from the clad surface with the plane separating the elements of the dual element search unit positioned parallel to the axis of the weld bead The search unit shall be moved perpendicular to the weld direction.

2) Technique Two

The examination may be performed from either the clad or unclad surface and the search unit may be moved either perpendicular or parallel to the weld direction.

7.4 Non-Distance Amplitude Techniques

The number of angles and directions of the scans shall be developed in the procedure and shall demonstrate the ability to detect the minimum size rejectable discontinuities in the referencing Code Section acceptance standards. The detailed techniques shall be in conformance with the requirements of the referencing Code Section.

8. Evaluation

8.1 General

It is recognized that not all ultrasonic reflectors indicate flaws, since certain metallurgical discontinuities and geometric conditions may produce indications that are not relevant. Included in this category are plate segregates in the heat-affected zone that become reflective after fabrication. Under straight beam examination, these may appear as spot or line indications. Under angle beam examination, indications that are determined to originate from surface conditions (such as weld root geometry) or variations in metallurgical structure in austenitic materials (such as the automatic-to-manual weld clad interface) may be classified as geometric indications. The identity, maximum amplitude. indication, and extent of reflector causing a geometric indication shall be recorded. [For example: internal attachment, 200% DAC, 1 in. (25 ㎜) above weld center line, on the inside surface, from 90 deg to 95 deg.] The following steps shall be taken to classify an indication as geometric:

1) Interpret the area is 25mm both side of weldment, as heat affect zone.
2) Plot and verify the reflector coordinates. Prepare a cross-sectional sketch showing the reflector position and surface discontinuities such as root and counterbore.
3) Review fabrication or weld preparation drawings. Other ultrasonic techniques or nondestructive examination methods may be helpful in determining a reflector's true position, size, and orientation.

8.2 Evaluation Level

1) Distance Amplitude Techniques

All indications greater than 20% of the reference level shall be investigated to the extent that they can be evaluated in terms of the acceptance criteria of the referencing code section.

2) Length Dimension for Planar Reflectors

The length of the reflector shall be obtained by recording the position and location along the length of the weld as determined by 20% of DAC for each end of the reflector.

8.3 Evaluation of Laminar Reflectors

Reflectors evaluated as laminar reflectors in base material which interfere with the scanning of examination volumes shall require the angle beam examination technique to be modified such that the maximum feasible volume is examined and shall be noted in the record of the examination .

8.4 Alternative Evaluations

Reflector dimensions exceeding the referencing Code Section requirements may be evaluated to any alternative standards provided by the referencing Code Section.

8.5 Method for sizing indication

8.5.1 6dB method

The extent of the defect is to be determined by maximizing the echo height in the middle of the defect, the echo height on the screen is noted and the probe is traversed towards the edge of the defect until the echo height has dropped to the 6dB(1/2).

8.5.2 Example for planar reflector

This chapter provides an example of the dimension a 120% DAC reflector found when scanning perpendicular to a weld.

1) Position the search unit to give the maximum amplitude from the reflector.
2) Read and record the maximum amplitude in percent of DAC
3) Read and record the sweep reading to reflector (at the left side of the indication on the sweep)
4) Read and record the search unit position with respect to the reference line.
5) Read and record the location of the indication at the beam center line intersection with respect to the reference line from the weld layout reference points. Move the search unit toward the reflector until the amplitude falls to 60% DAC (half maximum amplitude).
6) Read and record the minimum sweep reading.
7) Read and record the minimum search unit position.

Move the search unit away from the reflector past the maximum amplitude position until the amplitude falls to 60% DAC (half maximum amplitude)

8) Read and record the maximum sweep reading.
9) Read and record the maximum search unit position.
10) Subtract the minimum sweep reading from the maximum sweep reading and divide by the sweep reading for one wall thickness. Multiply by 100 and record as depth in % of t (t=weld thickness)
11) Subtract the maximum sweep reading from the sweep reading for one wall thickness or use the minimum sweep reading, whichever gives the smaller number. Divide the number by the sweep reading for one wall thickness. Multiply by 100 and record as distance from surface in % of t and length of reflection.

Successively read and record data along scan path at increments no greater than nine-tenths of the transducer (measured parallel to the scan increment change) at 60% DAC(half maximum amplitude). Continue scans until the maximum amplitude found at the end point of the reflector is 20% DAC.

The length of the reflector is the distance between the end points measured at the reflector. The length shall be divided by t and multiplied by 100 to give length in % of t.

8.6 Discriminating geometric from flaw indication as followings;

(a) Echo dynamic pattern from a Point Reflector (Fig. 7.1)

(b) Echo dynamic pattern from a fairly smooth extended defect-IP, LF (Fig. 7.2)

(c) Echo dynamic pattern from a large irregular reflector near normal incidence (Fig. 7.3)

(d) Echo dynamic pattern from a large irregular reflector at oblique incidence (Fig. 7.4)

(e) Echo dynamic pattern from a Multiple imperfection (Fig. 7.5)

(f) Effect of Curved surface on the A-scan response from a planar reflector (Fig. 7.6)

9. Acceptance Standards

9.1 ASME Section Ⅷ Div. 1 UW-53, Appendix 12

Imperfections which produce a response greater than 20% of the reference level shall be investigated to the extent that the operator can determine the shape, identity, and location of all such imperfections and evaluate them in terms of the acceptance standards given in 1) and 2) below.

1) Indications characterized as cracks, lack of fusion, or incomplete penetrations are unacceptable regardless of length.

2) Other imperfections are unacceptable if the indications exceed the reference level amplitude and have lengths which exceed:

(1) 1/4 in. (6 ㎜) for t up to 3/4 in. (19 ㎜);

(2) 1/3t for t from 3/4 in. to 2-1/4in. (19 ㎜ to 57 ㎜);

(3) 3/4 in.(19 ㎜) for t over 2-1/4 in. (57 ㎜).

Where t is the thickness of the weld excluding any allowable reinforcement. For a butt weld joining two members having different thicknesses at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in t.

3) Report of Examination.

The examiner shall prepare a report of the ultrasonic examination and the report shall contain the information required by Section V. In addition, a record of repaired areas shall be noted as well as the results of the reexamination of the repaired areas. The examiner shall also maintain a record of all reflections from uncorrected areas having responses that exceed 50% of the reference level. This record shall locate each area, the response level, the dimensions, the depth below the surface, and the classification.

9.2 ASME Section Ⅰ, PW-52

Imperfections that cause an indication greater than 20% of the reference level shall be investigated to the extent that the ultrasonic examination personnel can determine their shape, identity, and location, and evaluate them in terms of the acceptance standards given in 1) and 2) below

1) Cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length.

2) Other imperfections are unacceptable if the indication exceeds the reference level and their length exceeds the following:

(1) 1/4 in. (6 ㎜) for t up to 3/4 in. (19 ㎜);

(2) 1/3t for t from 3/4 in. to 2-1/4in. (19 ㎜ to 57 ㎜);

(3) 3/4 in. (19 ㎜) for t over 2-1/4in. (57 ㎜).

Where t is the thickness of the weld being examined. If the weld joins two members having different thicknesses at the weld, t is the thinner of these two thicknesses.

9.3 ASME B31.1 Chapter Ⅵ

Welds that are shown by ultrasonic examination to have discontinuities which produce an indication greater than 20% of the reference level shall be investigated to the extent that ultrasonic examination personnel can determine their shape, identity, and location so that they may evaluate each discontinuity for acceptance in accordance with 1) and 2) below.

1) Discontinuities evaluated as being cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length.

2) Other discontinuities are unacceptable if the indication exceeds the reference level and their length exceeds the following;

(1) 1/4 in. (6.0 ㎜) for t up to 3/4 in. (19.0 ㎜);

(2) 1/3t for t from 3/4 in. (19.0 ㎜) to 2 1/4in. (57.0 ㎜);

(3) 3/4in. (19.0 ㎜) for t over2 1/4in. (57.0 ㎜)

Where t is the thickness of the weld being examined. If the weld joins two members having different thicknesses at the weld, t is the thinner of these two thicknesses.

9.4 ASME SEC VIII Div.2 paragraph 7.5.4

All imperfections that produce an amplitude greater than 20% of the reference level shall be investigated to the extent that the operator can determine the shape, identity, and location of all such imperfections and evaluate them in terms of the acceptance standards given in (a) and (b) below.

(1) imperfections that are interpreted to be cracks, lack of fusion, or incomplete penetration are unacceptable regardless of length.

(2) All other linear type imperfections are unacceptnace if the amplitude exceeds the reference level and the length of the imperfection exceeds the following:

(a) 6mm(1/4in) for t less than 19mm(3/4in)

(b) t/3 for t greater than or equal to 19mm(3/4in) and less than or equal to 57mm(2 1/4in)

(c) 19mm(3/4in) for t greater than 57mm(2 1/4in)

In the above criteria, t is the thickness of the weld,excluding any allowable reinforcement. For a butt weld joining two members having different thickness at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in t.

10. Repairing

All unacceptable indications shall be repaired and re-examined at least with the same technique. All the ulatrasonic relating to repairing areas shall be recorded in the report and shall be re-evaluated in compliance with original acceptance criteria.

Subsequent repairs shall be identified by R1, R2, etc…

11. Documentation

11.1 Recording Indications

1) Non-Rejectable Indications

Non-Rejectable indications shall be recorded as specified by the referencing Code Section.

2) Rejectable Indications

Rejectable indications shall be recorded. As a minimum, the type of indication (i.e., crack, non-fusion. slag, etc.), location, and extent (i.e., length) shall be recorded.

10.2 Examination Records

For each ultrasonic examination, the following information shall be recorded:

1) Procedure identification and revision.

2) Ultrasonic instrument identification(including manufacture's s/n)

3) Search unit(s) identification(including manufacturer's serial number, frequency, and size)

4) beam angle(s) used

5) couplant used, brand name or type

6) search unit cable(s) used, type and length

7) special equipment when used(search units, wedges, shoes, automatic scanning equipment, recording equipment, etc.)

8) computerized program identification and revision when used

9) calibration sheet and block identification

10) simulation block(s) and electronic simulator(s) identification when used

11) instrument reference level gain and, if used, damping and reject setting(s)

12) calibration data [including reference reflector(s), indication amplitude(s) and distance reading(s)]

13) data correlation simulation block(s) and electronic simulator(s), when used, with initial calibration

14) identification and location of weld or volume scanned

15) surface(s) from which location of weld or volume scanned

16) map or record of rejectable indications detected or areas cleared

17) areas of restricted access or inaccessible weld

18) examination personnel identify and when required by referencing by referencing Code Section, qualification level

19) date of examination.

Items (2) through (12) may be included in a separate calibration record provided the calibration record identification is included in the examination record.

10.3 Performance Demonstration

Performance demonstration, when required by the referencing Code Section, shall be documented .

10.4 Report

A report of the examination shall be made. The report shall include those records indicated in 10.1 and 10.2. The report shall be filed and maintained in accordance with the referencing Code Section.

10.5 A report of the examination shall be signed and dated by the qualified and certified Level II who examined evaluation and disposition of the material or welds and approved by the Level II or Level III who performed the final acceptance of the results-Report shall be prepared and furnished to the client. Report of ultrasonic examination (Appendix-IV) will be used unless otherwise specified by client.

11. Appendix

Appendix I : Screen Height Linearity

Appendix II : Amplitude Control Linearity

Appendix III : Procedure Qualification for Essential/Nonessential variable

Appendix IV : Report of Ultrasonic Examination - 2 sheets

TABLE 1.

REQUIREMENTS OD A ULTRASONIC EXAMINATION PROCEDURE

Requirement	Essential Variable	Nonessential Variable	Paragraph No.
Weld Configurations to be examined, including thickness dimensions and base material product form (pipe, plate, etc.)	X		3.4/3.5
The surfaces from which the examination shall be performed	X		3.7
Technique(s) (straight beam, angle beam, contact, and/or immersion)	X		1.1 & 4.2
Angle(s) and mode(s) of wave propagation in the material	X		4.2
Search unit type(s), frequency(ies), and element size(s)/shape(s)	X		4.2
Special search units, wedges, shoes, or saddles, when used	X		None
Ultrasonic instrument(s)	X		4.1
Calibration [calibration block(s) and technique(s)]	X		4.4
Direction and extent of scanning	X		7.2
Scanning(manual vs. automatic)	X		4.1
Method for discriminating geometric from flaw indications	X		8.6
Method for sizing indications	X		8.5
Computer enhanced data acquisition, when used	X		None
Scan overlap(decrease only)	X		7.1 1)
Personnel performance requirement, when required	X		10.3
Personnel qualification requirement		X	3.2
Surface condition(examination surface, calibration block)		X	4.4 & 7.1
Couplant: brand name and/or type		X	4.3
Automatic alarm and/or recording equipment, when applicable		X	None
Record, including minimum calibration data to be recorded(e.g., instrument settings)		X	10.2

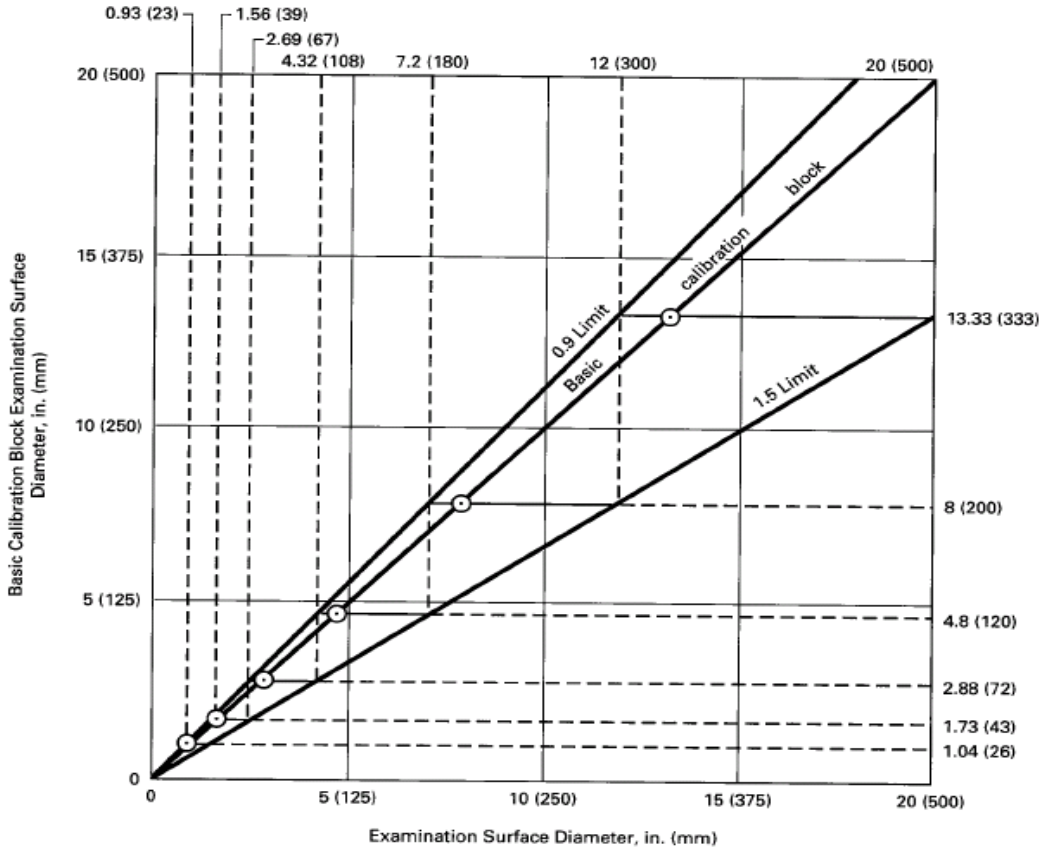


Fig. 1 Ratio Limits for Curved Surfaces

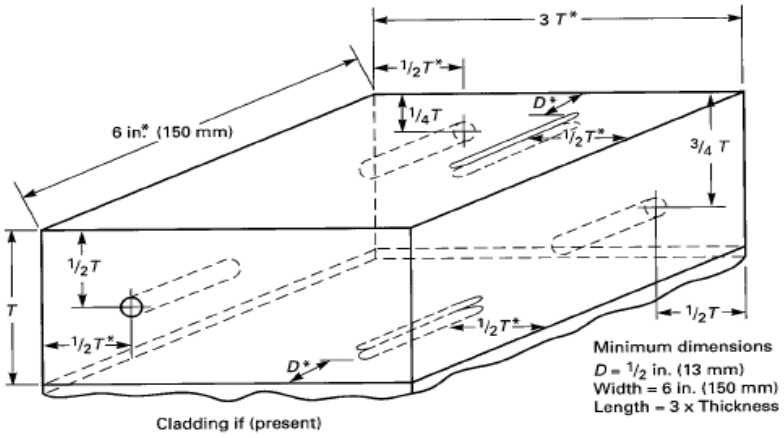


Fig 2. Non-Piping Calibration Block

Weld Thickness(t), in. (mm)	Calibration Block Thickness(T) in. (mm)	Hole Diameter In. (mm)	Notch Dimensions in. (mm)
Up to 1(25) Over 1(25) through 2(50) Over 2(50) through 4(100) Over 4(100)	¾ (19) or t 1½ (38) or t 3 (75) or t t ± 1 (25)	3/32 (2.5) 1/8 (3) 3/16 (5) **	Notch Depth = 2% T Notch Width = 1/4 (6) max. Notch Length = 1 (25) min.

* Mimimun dimension

General Notes :

(a) Holes shall be drilled and reamed a minimum of 1½ in. (38 ㎜) deep, essentially parallel to the examination surface.

(b) For components equal to or less 20 in. (500 ㎜) in diameter, calibration block diameter shall meet the requirement of T-434.1.7.2.(Asme Sec. Ⅴ Art. 4) Two sets of calibration reflectors (holes, notches) oriented 90 deg from each other shall be used. Alternatively, two curved calibration blocks may be used

(c) The tolerance for hole diameter shall be ±1/32 in.(0.8 ㎜). The tolerance for hole location through the calibration block thickness(i.e., distance from the examination surface) shall be ±1/8 in.(3 ㎜)

(d) For blocks less than 3/4 in.(19 ㎜) in thickness, only the 1/2T side-drilled hole and surface notches are required.

(e) All holes may be located on the same face(side) of the calibration block, provided care is exercised to locate all the reflectors(holes, notches) to prevent on reflectors from affecting the indication from another reflector during calibration. Notches may also be in same plane as the inline holes(See ASME Sec. Ⅴ Art. 4 Appendix J, FIG. J-431). As in Fig. 431, a sufficient number of holes shall be provided for both angle and straight beam calibrations at the 1/4T, 1/2T and 3/4T depths.

(f) Minimum notch depth shall be 1.6% T and maximum notch depth shall be 2.2% T plus the thickness of cladding, if present

(g) Maximum notch width is not critical. Notches may by EDM or with end mills up to 1/4 in.(6.4 ㎜) in diameter.

(h) Weld thickness, t, is the nominal material thickness for welds without reinforcement or, for welds with reinforcement, the nominal material thickness plus the estimated weld reinforcement not to exceed the maximum permitted by the referencing Code Section. When two or more base material thicknesses are involved, the calibration block thickness, T, shall be determined by the average thickness of the weld; alternatively, a calibration block based on the greater base material thickness may be used provided the reference reflector size is based upon the average weld thickness.

Notes : (1) For each increase in weld thickness of 2 in. (50 ㎜) or fraction thereof over 4 in. (100 ㎜), the hole diameter shall increase 1/16 in. (1.5 ㎜)

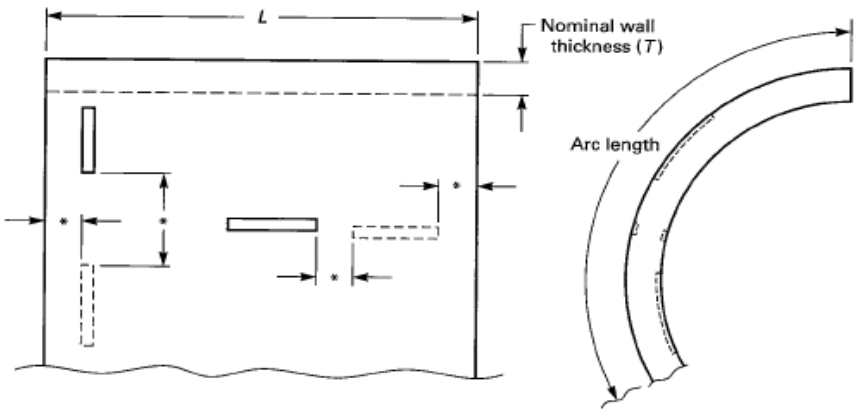


Fig. 3 Calibration Block For Pipe

* Notches shall be located not closer than T or 1 in. (25 ㎜), whichever is greater, to any block edge or to other notches.

GENERAL NOTES:

(a) The minimum calibration block length (L) shall be 8 in. (200 ㎜) or 8T, whichever is greater.

(b) For OD 4 in. (100 ㎜) or less, the minimum arc length shall be 270 deg. For OD greater than 4 in. (100 ㎜), the minimum arc length shall be 8 in. (200 ㎜) or 3T, whichever is greater.

(C) Notch depths shall be from 8% T minimum to 11% T maximum. Notch widths shall be 1/4in. (6.4 ㎜) maximum. Notch lengths shall be 1 in.(25 ㎜) minimum.

(d) Maximum notch width is not critical. Notches may by made with EDM or with end mills up to 1/4 in. (6 ㎜) in diameter

(e) Notch length shall be sufficient to provide for calibration with a minimum 3 to 1 signal-to-noise ratio.

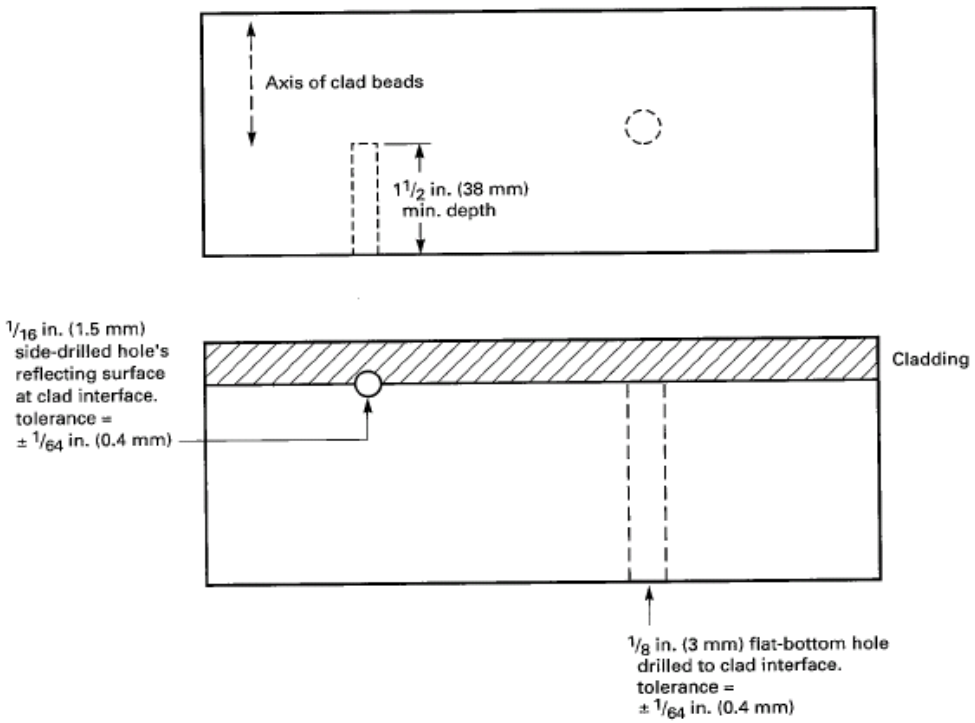


Fig. 4 Calibration Block for Technique One

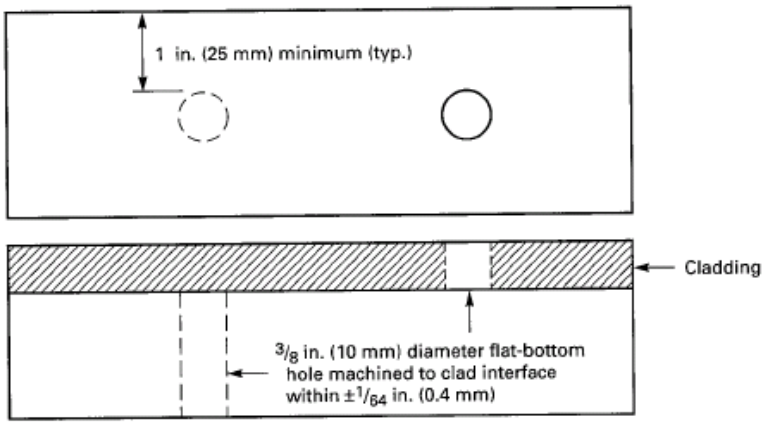


Fig. 5 Calibration Block for Technique Two

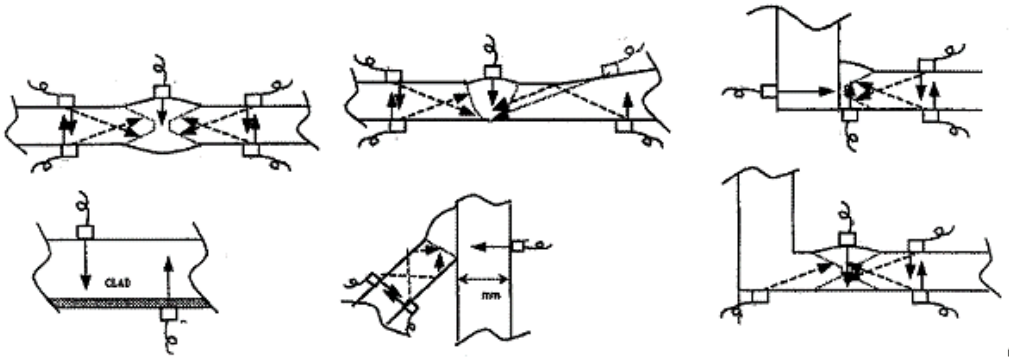


Fig. 6 weld configuration and Directions/extend of scanning

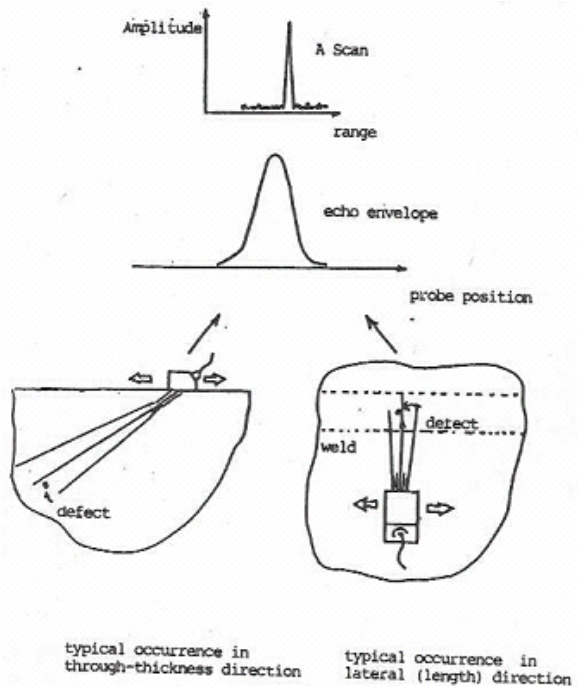


Fig. 7.1 Echo dynamic pattern from a Point Reflector

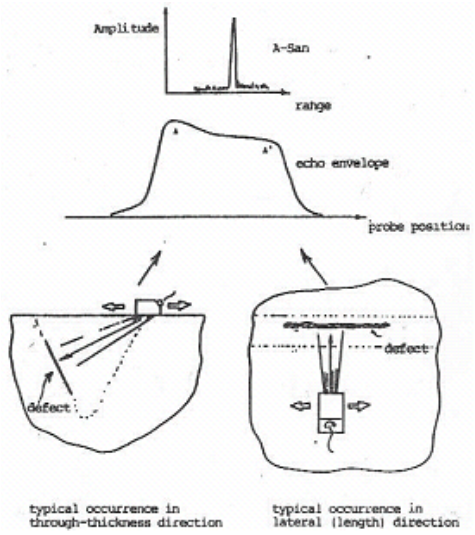


Fig. 7.2 Echo dynamic pattern from a Fairly smooth extended defect-IP, LF

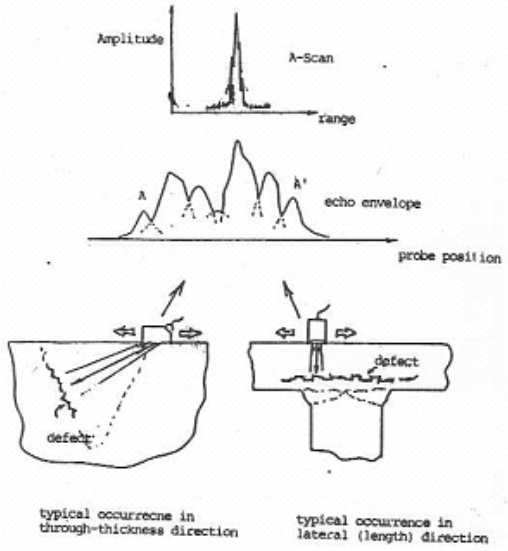


Fig. 7.3 Echo dynamic pattern from a Large irregular reflector near normal incidence

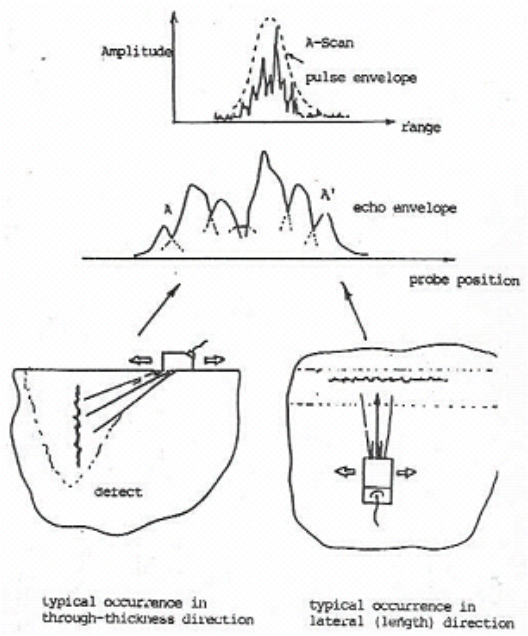


Fig. 7.4 Echo dynamic pattern from a Large irregular reflector at oblique incidence

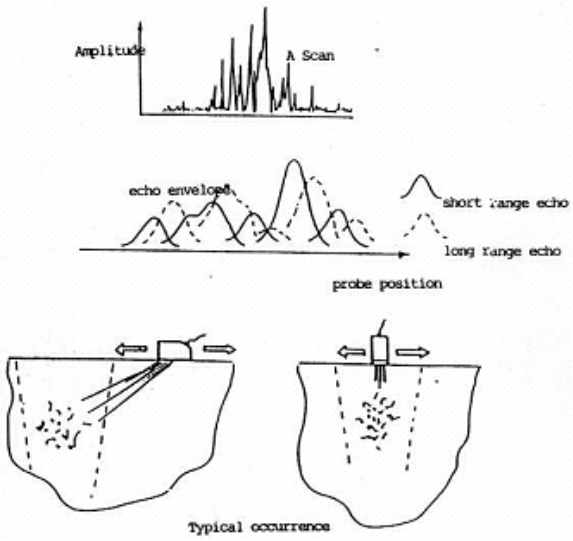


Fig. 7.5 Echo dynamic pattern from a Multiple imperfection

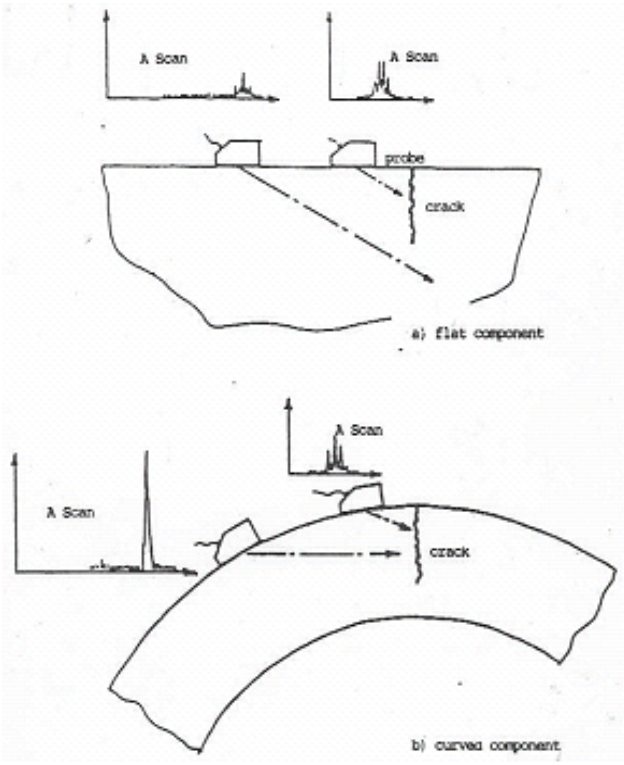


Fig. 7.6 Effect of curved surface on the A-scan response from a planar reflector

Appendix- I Screen Height Linearity

1. Scope

This Appendix provides requirements for checking screen height linearity and is applicable to ultrasonic instruments with A-scan displays.

2. Miscellaneous Requirements

Position an angle beam search unit on a calibration block, as shown in Fig.6 so that indications from both the 1/2 and 3/4 T holes give a 2:1 ratio of amplitudes between the two indications. Adjust the sensitivity (gain) so that the larger indication is set at 80% of full screen height (FSH). Without moving the search Unit, adjust the sensitivity (gain) to successively set the larger indication from 100% to 20% of full screen height, in 10% increments (or 2dB steps if a fine control is not available), and read the smaller indication at each setting.

The reading shall be 50% of the larger amplitude, within 5% of FSH.

The settings and readings shall be estimated to the nearest 1% of full screen.

Alternatively, a straight beam search unit may be used on any calibration block that will provides amplitude differences, with sufficient signal separation to prevent overlapping of the two signals.

Appendix II Amplitude Control Linearity

1. Scope

   This Appendix provides requirements for checking amplitude control linearity and is applicable to ultrasonic instruments with A-scan displays.

2. Miscellaneous Requirements

   Position an angle beam search unit on a basic calibration block, as shown in Fig. 6 so that the indication from the 1/2T side-drilled hole is peaked on the screen.

   Adjust the sensitivity (gain) as shown in the following table.

   The indication shall fall within the specified limits.

   Alternatively, any other convenient reflector from any calibration block may be used with angle or straight beam search units. .

Indication Set at % of Full Screen	dB Control Change	Indication Limits % of Full Screen
80 %	- 6dB	32 to 48 %
80 %	-12dB	16 to 24 %
40 %	+ 6dB	64 to 96 %
20 %	+12dB	64 to 96 %

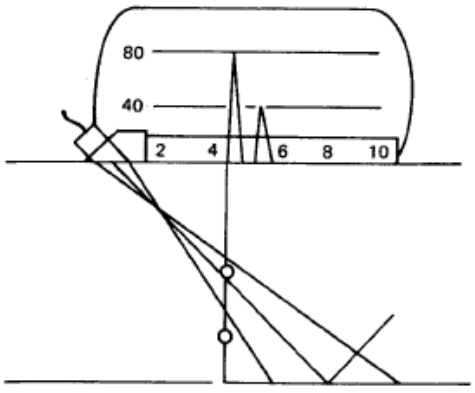


Fig 6. Linearity

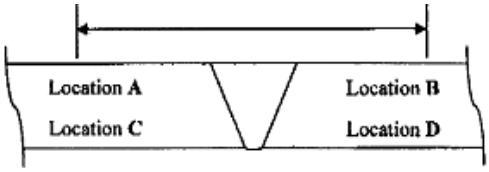
Appendix Ⅲ : Procedure Qualification for Essential/Nonessential variable

Table-1

Procedure Qualification for Essential/Nonessential variable page 1 of 3

Essential variable		**butt welds of ferrous material**		
1	Weld configurations (thickness/base material product form)	Up to 25 ㎜	Over 25 ㎜ through 51 ㎜	Over 51 ㎜ through 102 ㎜
2	Personnel performance requirement	ASNT/SNT-TC-1A, UT Level Ⅱ/Ⅲ		
3	Examination surface form	As weld		
4	Techniques	Direct contact method		
5	Angles and modes of wave propagation	0°(longitudinal) 45°(transverse) 60 or70°(transverse)	0°(longitudinal) 45°(transverse) 60 or70°(transverse)	0°(longitudinal) 45°(transverse) 60°(transverse)
6	Search unit type/ frequencies/ element sizes/ shapes	MB4S(ø10):Circular MWB45(8×9 ㎜): reticular MWB60 or70(8×9 ㎜): reticular 4 ㎒	B2S(ø24):Circular MWB45(8×9,14×14 ㎜): reticular MWB60 or70(8×9,14×14 ㎜): reticular 2 ㎒	B2S(ø24):Circular MWB45(8×9,14*14,20*22 ㎜): reticular MWB60(8×9,14*14,20*22 ㎜): reticular 2 ㎒
7	Special search unit wedges, shoes, or saddles	Not applicable		
8	Ultrasonic instrument	Model : SITESCAN Maker : SONATEST		

Procedure Qualification for Essential/Nonessential variable page 2 of 3

<table>
<tr><td colspan="2">Essential variable</td><td colspan="3">butt welds of ferrous material</td></tr>
<tr><td rowspan="4">9</td><td rowspan="4">Calibration (block/technique)</td><td colspan="3">Non-piping calibration block
(ASME Sec. Ⅴ, Art.4, Fig. T-434.2.1)</td></tr>
<tr><td colspan="3">Calibration block thicknesses</td></tr>
<tr><td>19 ㎜</td><td>38 ㎜</td><td>76 ㎜</td></tr>
<tr><td colspan="3">Calibration in accordance with
ASME Sec. Ⅴ, Art.4, para T-461, 462, 463</td></tr>
<tr><td rowspan="3">10</td><td rowspan="2">Directions location
of scanning</td><td>Location
A & B</td><td>Location
A, B, C, & D</td><td>Location
A, B, C, & D</td></tr>
<tr><td colspan="3"> 

Extent of Scanning</td></tr>
<tr><td>Extent of scanning</td><td>Min. 90 ㎜
from center of
weldment</td><td>Min. 180 ㎜
from center of
weldment</td><td>Min. 225 ㎜
from center of
weldment</td></tr>
<tr><td>11</td><td>Scanning(Manual
or automatic)</td><td colspan="3">Scanning by manual</td></tr>
<tr><td>12</td><td>Method for discriminating geometric
From flow indications</td><td colspan="3">In accordance with para 8.6 in this procedure</td></tr>
<tr><td>13</td><td>Method for sizing indication</td><td colspan="3">In accordance with para 8.5 in this procedure</td></tr>
<tr><td>14</td><td>Computer enhanced data
acquisition</td><td colspan="3">Not applicable</td></tr>
<tr><td>15</td><td>Scan overlap
(Decrease only)</td><td colspan="3">Minimum 10% of the active transducer dimension</td></tr>
</table>

Procedure Qualification for Essential/Nonessential variable

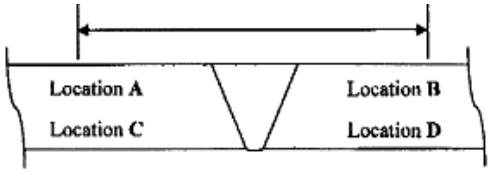
Nonessential variable		butt welds of ferrous material		
1	Personnel qualification requirements	ASNT/SNT-TC-1A and/or sub contractor's written practice		
2	Surface condition (examination/calibration block)	Calibration block is equal to examination surface		
3	Couplant (brand name or type)	Carboxy Methyl Cellulose Maker : Gojae / Korea		
4	Automatic alarm and/or Recording equipments	Not applicable		
5	Records, including min. calibration data (instrument settings)	Not applicable		
PROCEDURE QUALIFICATION TEST		Test Report No.: UTR-01A	Test Report No.: UTR-01B	Test Report No.: UTR-01C

Table-2

Procedure Qualification for Essential/Nonessential variable page 1 of 3

Essential variable		**butt welds of non-ferrous material(Austenite steel)**		
1	Weld configurations (thickness/base material product form)	Up to 25 ㎜	Over 25 ㎜ through 51 ㎜	Over 51 ㎜ through 102 ㎜
2	Personnel performance requirement	ASNT/SNT-TC-1A, UT Level Ⅱ/Ⅲ		
3	Examination surface form	As weld		
4	Techniques	Direct contact method		
5	Angles and modes of wave propagation	0°(longitudinal) 60°(longitudinal) 70°(longitudinal)	0°(longitudinal) 45°(longitudinal) 60 or 70°(longitudinal)	0°(longitudinal) 75° ~ 85° (creeping wave) 45°(longitudinal) 60°(longitudinal)
6	Search unit type/ frequencies/ element sizes/ shapes	MB4S(ø10):Circular 2C8*14LAD60 (8×14 ㎜):reticular 2C8*14LAD70 (8×14 ㎜): reticular 2 ㎒	B2S(ø24):Circular 2C8*14LAD45 (8×14,10×18 ㎜):reticular 2C8*14LAD70 (8×14,10×18 ㎜): reticular 2 ㎒	B2S(ø24):Circular 2C10*18LAD45(10×18 ㎜): reticular 2C10*18LAD45 (10×18 ㎜): reticular 2 ㎒
7	Special search unit wedges, shoes, or saddles	Not applicable		
8	Ultrasonic instrument	Model : SITESCAN Maker : SONATEST		

Procedure Qualification for Essential/Nonessential variable page 2 of 3

<table>
<tr><td colspan="2">Essential variable</td><td colspan="3">butt welds of non-ferrous material(Austenite steel)</td></tr>
<tr><td rowspan="4">9</td><td rowspan="4">Calibration
(block/technique)</td><td colspan="3">Non-piping calibration block
(ASME Sec. Ⅴ, Art.4, Fig. T-434.2.1)</td></tr>
<tr><td colspan="3">Calibration block thicknesses</td></tr>
<tr><td>19 ㎜</td><td>38 ㎜</td><td>76 ㎜</td></tr>
<tr><td colspan="3">Calibration in accordance with
ASME Sec. Ⅴ, Art.4, para T-461, 462, 463</td></tr>
<tr><td rowspan="2">10</td><td rowspan="2">Directions location
of scanning</td><td>Location
A & B</td><td>Location
A, B, C, & D</td><td>Location
A, B, C, & D</td></tr>
<tr><td colspan="3">Extent of Scanning
 
</td></tr>
<tr><td></td><td>Extent of scanning</td><td>Weld &
HAZ(½ skip)</td><td>Weld &
HAZ(½ skip)</td><td>Weld &
HAZ(½ skip)</td></tr>
<tr><td>11</td><td>Scanning(Manual or
automatic)</td><td colspan="3">Scanning by manual</td></tr>
<tr><td>12</td><td>Method for discriminating
geometric
From flow indications</td><td colspan="3">In accordance with para 8.6 in this procedure</td></tr>
<tr><td>13</td><td>Method for sizing indication</td><td colspan="3">In accordance with para 8.5 in this procedure</td></tr>
<tr><td>14</td><td>Computer enhanced data
acquisition</td><td colspan="3">Not applicable</td></tr>
<tr><td>15</td><td>Scan overlap
(Decrease only)</td><td colspan="3">Minimum 10% of the active transducer dimension</td></tr>
</table>

Procedure Qualification for Essential/Nonessential variable

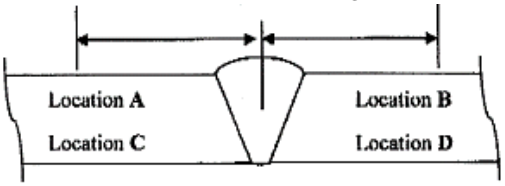
Nonessential variable		**butt welds of non-ferrous material(Austenite steel)**		
1	Personnel qualification requirements	ASNT/SNT-TC-1A and/or sub contractor's written practice		
2	Surface condition (examination/calibration block)	Calibration block is equal to examination surface		
3	Couplant (brand name or type)	Carboxy Methyl Cellulose Maker : Gojae / Korea		
4	Automatic alarm and/or Recording equipments	Not applicable		
5	Records, including min. calibration data (instrument settings)	Not applicable		
PROCEDURE QUALIFICATION TEST		Test Report No.: UTR-01A	Test Report No.: UTR-01B	Test Report No.: UTR-01C

Table-3

Procedure Qualification for Essential/Nonessential variable page 1 of 3

Essential variable		**butt welds of non-ferrous material(Clad steel)**		
1	Weld configurations (thickness/base material product form)	Up to 25 ㎜	Over 25 ㎜ through 51 ㎜	Over 51 ㎜ through 102 ㎜
2	Personnel performance requirement	ASNT/SNT-TC-1A, UT Level Ⅱ/Ⅲ		
3	Examination surface form	As weld		
4	Techniques	Direct contact method		
5	Angles and modes of wave propagation	0°(longitudinal) 60°(transverse) 70°(transverse)	0°(longitudinal) 45°(transverse) 60or 70°(transverse)	0°(longitudinal) 45°(transverse) 60°(transverse)
6	Search unit type/ frequencies/ element sizes/ shapes	MB4S(ø10):Circular MWB60(8×9 ㎜): reticular MWB70(8×9 ㎜): reticular 4 ㎒	B2S(ø24):Circular MWB45(8×9,14×14 ㎜): reticular MWB60 or70(8×9,14×14 ㎜): reticular 2 ㎒	B2S(ø24):Circular MWB45(8×9,14*14,20*22 ㎜): reticular MWB60(8×9,14*14,20*22 ㎜): reticular 2 ㎒
7	Special search unit wedges, shoes, or saddles	Not applicable		
8	Ultrasonic instrument	Model : SITESCAN Maker : SONATEST		

Procedure Qualification for Essential/Nonessential variable

<table>
<tr><td colspan="2">Essential variable</td><td colspan="3">butt welds of non-ferrous material(Clad steel)</td></tr>
<tr><td rowspan="4">9</td><td rowspan="4">Calibration
(block/technique)</td><td colspan="3">Non-piping calibration block
(ASME Sec. Ⅴ, Art.4, Fig. T-434.2.1)</td></tr>
<tr><td colspan="3">Calibration block thicknesses</td></tr>
<tr><td>19 ㎜</td><td>38 ㎜</td><td>76 ㎜</td></tr>
<tr><td colspan="3">Calibration in accordance with
ASME Sec. Ⅴ, Art.4, para T-461, 462, 465</td></tr>
<tr><td rowspan="3">10</td><td rowspan="2">Directions location
of scanning</td><td>Location
A & B</td><td>Location
A, B, C, & D</td><td>Location
A, B, C, & D</td></tr>
<tr><td colspan="3">Extent of Scanning
 
</td></tr>
<tr><td>Extent of scanning</td><td>Min. 90 ㎜
from center of
weldment</td><td>Min. 180 ㎜
from center of
weldment</td><td>Min. 225 ㎜
from center of
weldment</td></tr>
<tr><td>11</td><td>Scanning(Manual or
automatic)</td><td colspan="3">Scanning by manual</td></tr>
<tr><td>12</td><td>Method for discriminating geometric
From flow indications</td><td colspan="3">In accordance with para 8.6 in this procedure</td></tr>
<tr><td>13</td><td>Method for sizing indication</td><td colspan="3">In accordance with para 8.5 in this procedure</td></tr>
<tr><td>14</td><td>Computer enhanced data
acquisition</td><td colspan="3">Not applicable</td></tr>
<tr><td>15</td><td>Scan overlap
(Decrease only)</td><td colspan="3">Minimum 10% of the active transducer dimension</td></tr>
</table>

Procedure Qualification for Essential/Nonessential variable

Nonessential variable		**butt welds of non-ferrous material(Clad steel)**		
1	Personnel qualification requirements	ASNT/SNT-TC-1A and/or sub contractor's written practice		
2	Surface condition (examination/calibration block)	Calibration block is equal to examination surface		
3	Couplant (brand name or type)	Carboxy Methyl Cellulose Maker : Gojae / Korea		
4	Automatic alarm and/or Recording equipments	Not applicable		
5	Records, including min. calibration data (instrument settings)	Not applicable		
PROCEDURE QUALIFICATION TEST		Test Report No.: UTR-01A	Test Report No.: UTR-01B	Test Report No.: UTR-01C

Table-4

Procedure Qualification for Essential/Nonessential variable

Essential variable		Plate of ferrous material
1	Weld configurations (thickness/base material product form)	Rolled fully killed carbon and alloy steel plate, 25 ㎜ and over in thickness
2	Personnel performance requirement	ASNT/SNT-TC-1A, UT Level Ⅱ/Ⅲ
3	Examination surface form	As plate
4	Techniques	Direct contact method
5	Angles and modes of wave propagation	0°(longitudinal)
6	Search unit type/ frequencies/ element sizes/ shapes	B2S(ø24) : circular 2 ㎒
7	Special search unit wedges, shoes, or saddles	Not applicable
8	Ultrasonic instrument	Model : SITESCAN Maker : SONATEST

Procedure Qualification for Essential/Nonessential variable page 2 of 3

Essential variable		Plate of ferrous material
9	Calibration (block/technique)	Back reflection technique
10	Directions and extent of scanning	Perpendicular grid lines on normal 9 in.(225 ㎜) centers, and 2 in. of all edges of plate
11	Scanning(Manual or automatic)	Scanning by manual
12	Method for sizing indication (Applicable code)	ASME Sec. Ⅴ Art.23 SA-435 para. 6
13	Computer enhanced data acquisition	Not applicable
14	Scan overlap (Decrease only)	Minimum 10% of the active transducer dimension

Procedure Qualification for Essential/Nonessential variable

Nonessential variable		Plate of ferrous material
1	Personnel qualification requirements	ASNT/SNT-TC-1A and/or sub contractor's written practice
2	Surface condition (examination/calibration block)	Calibration block is equal to examination surface
3	Couplant (brand name or type)	Carboxy Methyl Cellulose Maker : Gojae / Korea
4	Automatic alarm and/or Recording equipments	Not applicable
5	Records, including min. calibration data (instrument settings)	Not applicable
APPLICABLE ITEM PART		This procedure will be applicable code specification

Table-5

Procedure Qualification for Essential/Nonessential variable page 1 of 3

Essential variable		**Clad plate of ferrous material**
1	Weld configurations (thickness/base material product form)	Rolled carbon and alloy steel plain, and clad steel plates, 10 ㎜ and over in thickness
2	Personnel performance requirement	ASNT/SNT-TC-1A, UT Level Ⅱ/Ⅲ
3	Examination surface form	As plate
4	Techniques	Direct contact method
5	Angles and modes of wave propagation	0°(longitudinal)
6	Search unit type/ frequencies/ element sizes/ shapes	B4S(ø24) : circular 4 ㎒
7	Special search unit wedges, shoes, or saddles	Not applicable
8	Ultrasonic instrument	Model : SITESCAN Maker : SONATEST

Procedure Qualification for Essential/Nonessential variable page 2 of 3

Essential variable		**Clad plate of ferrous material**
9	Calibration (block/technique)	Back reflection technique
10	Directions and extent of scanning	Perpendicular grid lines on normal 9 in.(225 ㎜) centers, and 2 in. of all edges of plate
11	Scanning(Manual or automatic)	Scanning by manual
12	Method for sizing indication (Applicable code)	ASME Sec. Ⅴ Art.23 SA-578 para. 7
13	Computer enhanced data acquisition	Not applicable
14	Scan overlap (Decrease only)	Minimum 10% of the active transducer dimension

Procedure Qualification for Essential/Nonessential variable page 3 of 3

Nonessential variable		**Clad plate of ferrous material**
1	Personnel qualification requirements	ASNT/SNT-TC-1A and/or sub contractor's written practice
2	Surface condition (examination/calibration block)	Calibration block is equal to examination surface
3	Couplant (brand name or type)	Carboxy Methyl Cellulose Maker : Gojae / Korea
4	Automatic alarm and/or Recording equipments	Not applicable
5	Records, including min. calibration data (instrument settings)	Not applicable
APPLICABLE ITEM PART		This procedure will be applicable code specification

Appendix Ⅳ : Report of Ultrasonic Examination - A

초 음 파 탐 상 검 사 보 고 서
REPORT OF ULTRASONIC EXAMINATION

SUNG JIN GEOTEC CO., LTD
#20-1,SUNG AM-DONG,NAM-KU,ULSAN,KOREA
TEL:(052)228-5801~4,FAX(052)228-5989

Report No. 보고서번호	
Page No. 페이지번호	

Project Name 공사명	Owner / Customer 주문주/고객	Job No. 공사번호
Item Name / 제품명	Item No / 제품 번호	Drawing No. 도면번호 Rev No.
Surface Condition 표면조건	Cable Type & Length	Examined Date & time
○AS-Welded ○AS-Ground ○AS-Rolled		&

Testing Equip(Type) 검사장비/Sr.No.	Calibration Block 교정시편 / I.D No.	Proves Used 탐 촉 자			
	○ STB-A1 ○ IIW-Type1 /	Angle	Frequency	Size (mm)	Serial No.
Calibration data 교정기록	SGT R/Block 대비시편 / I.D No.		Mhz		
R/B Thickness :	I.D No :		Mhz		
Angle / R/reflector / Amplitude / Distance	Type : ○ Side - Drilled Hole ○ V - Notch ○ Square Notch ○ Flat - Bottom Hole		Mhz		
			Mhz		
			Mhz		
	Notch & Hole Size : mm		Mhz		
	Couplant Used 탐상 매질	Gate setting / Damping and rejection			
	○ CMC + Water ○ Glycerin	○ On ○ Off			

Acceptance Standard & Applicable procedures / 합격기준 및 적용절차서

Examination technique 검사 기법

Transfer Loss check perform once for each welded joint to be examined, except that for repetitive test of same materials.
같은 재질일 경우를 제외하고, 검사할 시편(용접부)과 대비 시편이 다를 경우, 전달손실을 체크한다.

Defect Code 결함약호

♣ Draw a sketch of each rejected indication on attached sheet (서류상에 불합격된 지시치는 첨부 스케치 한다.)
1) Measured form '0' - Position ('0' 위치로 부터 측정)
2) P = Porsity 기공 IN = Inclusion(slag) 불순물 LF = Lack of Fusion 융합 불량
IP = Incomplete Penetration 용입 불량 Cr = Crack 균열 F = Others 기타

Weld Line & Spool No.	Indication. Flaw (mm)						Discontinuity evaluation 불연속의 평가		Weld Material & thickness 용접재료및두께	Welding length & Test length 용접길이 및 검사길이		Remark 비 고
	Location 결함위치	Defect Depth 결함깊이	Defect Length 결함길이	Defect type 결함 형태	Max. Resp (Dac%) 높 이	Scope 영 역	Accept 합격	Reject 불합격		Total 합계	Test 검사	

NDT.Co Operator (Level II)	Witnessed by QC (Level II)	Approved.By LEVEL III	Reviewed by Client	Reviewed by AI

Appendix Ⅳ : Report of Ultrasonic Examination - B

초 음 파 탐 상 검 사 보 고 서
REPORT OF ULTRASONIC EXAMINATION

SUNG JIN GEOTEC CO., LTD
#20-1,SUNG AM-DONG,NAM-KU,ULSAN,KOREA
TEL:(052)228-5801~4,FAX(052)228-5989

Report No. 보고서번호	
Page No. 페이지번호	

Defect Code 결함약호

♣ Draw a sketch of each rejected indication on attached sheet (서류상에 불합격된 지시치는 첨부 스케치 한다.)
1) Measured form '0' – Position ('0' 위치로 부터 측정)
2) P = Porsity 기공 IN = Inclusion(slag) 불순물 LF = Lack of Fusion 융합 불량
IP = Incomplete Penetration 용입 불량 Cr = Crack 균열 F = Others 기타

Weld Line & Spool No.	Indication. Flaw (mm)						Discontinuity evaluation 불연속의 평가		Weld Material & thickness 용접재료및두께	Welding length & Test length 용접길이 및 검사길이		Remark 비 고
	Location 결함위치	Defect Depth 결함깊이	Defect Length 결함길이	Defect type 결함 형태	Max. Resp (Dac%) 높이	Scope 영역	Accept 합격	Reject 불합격		Total 합계	Test 검사	

Ⅲ. Magnetic particle Examination Procedure

TABLE OF CONTENTS

1. Scope

1.1 This procedure describes the minimum requirements for techniques to be used when performing yoke method, wet magnetic particle examination of materials and weldments in accordance with the requirements of ASME Section V Article 7.

1.2 This procedure describes the general requirements for safety. materials, equipment, personnel, technique and acceptance criteria. When differences exist between this procedure and technical specification, the technical specification shall govern.

1.3 The materials, shapes, or sizes to be examined, and the extent of the examination shall be in accordance with manufacturing drawing. Magnetic particle examination (AC Yoke technique) shall be used for detecting discontinuities to be found on base materials, weldments. weld edge preparation, forging and bar etc. of the which the components and parts are manufactured with carbon steel materials for boilers, heat exchangers and pressure vessels.

2. References

2.1 ASME Sec. Ⅰ Power Boiler (2007 Edition)

2.2 ASME Sec. V Nondestructive Examination (2007 Edition-2009ADD)

2.3 ASME Sec. Ⅷ Div.1 &Div.2 Rules for construction of Pressure Vessels (2007 Edition-2009ADD)

2.4 ASME B31.1 Power Piping (2007 Edition-2009ADD)

2.5 ASME Ⅸ Welding and Brazing Qualification (2007 Edition-2009ADD)

2.6 ASNT Recommended Practice No. SNT-TC-1A for NDT Personnel Qualification and Certification (2006 Ed.)

3. Qualification Requirements

3.1 Procedure Qualification

This procedure shall be qualified before use according to the table1, using the form “Procedure Qualification for Essential/Nonessential variable".

3.2 Personnel Qualification

1) Personnel shall be qualified and certified in accordance with the employer written practice that shall meet SNT-TC-1A.

2) Only qualified and certified Level Ⅱ or Level Ⅲ Personnel shall make determinations to the acceptability of examination results.

3.3 Procedure Requirements

1) Magnetic particle examination shall be performed in accordance with a written procedure which shall as a minimum, contain the requirements listed in Table1. The written procedure shall

establish a single value, or range of values, for each requirement. If required any additional written procedures will need to be submitted to the Purchaser's inspector for review prior to use.

2) When procedure qualification is specified, a change of requirement in Table 1 identified as an essential variable from the specified value, or range of values, shall require requalification of the written procedure. A change of a requirement identified as a nonessential variable from the specified value, or range of values, does not require requalification of the written procedure. All changes of essential or nonessential variables from the value, or range of values, specified by the written procedure shall require revision of, or an addendum to, the written procedure.

3.4 Specification Requrirements

1) General Requirements

1.1) Magnetic particle examination shall be made in the following locations:

a) Plate edges greater than 50 mm in thickness, prior to welding, for detection of laminations or cracks. Plate edge laminations shall not exceed 12 mm in length. Cracks are not permitted and shall be repaired.

b) All back-chipped or gouged surfaces prepared for second-side welding.

c) For Division 1 construction, the surfaces of all welds joining heavily loaded attachments to the vessel internal or external surface, e.g., vessel support rings, lugs or saddles, brackets, and rings supporting internal catalyst bed gratings.

d) For Division 2 construction, the surfaces of all permanent attachment welds, such as internally or externally attached lugs, rings, brackets, supports, or clips.

e) The inside and outside surfaces of all seams and nozzle attachment welds.

f) Built-up weld deposits in Division 2 construction shall have the first weld layer and the completed weld build-up surface, together with all adjacent base metal surfaces within 50 mm of the build-up examined.

g) The surface of all weld repairs. All repairs shall be made by a procedure that has been approved by the CONTRACTOR.

2) All attachment fillet welds to the pressure parts shall be ground smooth and radiussed and 100% magnetic particle examination carried out.

3) After removal of temporary lugs, erection cleats and other fit-up attachments, any remaining weld metal protuberance shall be ground flush with the surface of the part, and the area shall be inspected for cracks using liquid penetrant or magnetic particle testing.

4. Equipment and Materials

4.1 Examination Medium

The finely divided ferromagnetic particles used for the examination shall meet the following requirements. The particles shall be treated to impart color (nonfluorescent pigments) in order to make them highly visible (contrasting) against the background of the surface being examined.

1) Wet Particles

Wet magnetic particles are designed to be suspended in a vehicle such as water or light petroleum distillate at a given concentration for application to the test surface by flowing, spraying, or pouring.

2) Temperature Limitation

In this procedure, particles and examination pad surface temperature shall be within the temperature range limitations set by the manufacturer of the particle. The temperature of the wet particle suspension and surface of the pad shall not exceed 120°F (49℃) for nonfluorescent particles. Alternatively particles may be used outside the particle manufacturer's recommendations providing the procedure is qualified in accordance with ASME Section V Article 1, T-150 at the proposed temperature.

3) The following materials shall be used with this procedure. The manufacturer shall provide materials with a certificate of material analysis to SGT.

	Type		Brand Name		
	Method	type	GS CHEM	NAWOO	KYUNGDO
Magnetic Particle	Nonfluorescent	Wet	MPS-B	NMP-B	7C-BLACK
	fluorescent	Wet	MPS-F	NMP-F	14AM
Paints	Both above	Wet	MMP-W	NMP-1	WMP

4.2 Magnetic Field Adequacy and Direction

1) Magnetic Field Adequacy

The applied magnetic field shall have sufficient strength to produce satisfactory Indications, but shall not be so strong that it causes masking of relevant indications by nonrelevant accumulations of magnetic particles. Factors that influence the required field strength include the size, shape, and material permeability of the part; the technique of magnetization; coatings; the method of particle application; and the type and location of discontinuities to be detected. When it is necessary to verify the adequacy of magnetic field strength, it shall be verified by using pie-shaped magnetic particle field indicator. The indicator shall be positioned on the surface to be examined, such that the copper-plated side is away from the inspected surface. A suitable field strength is indicated when a Clearly defined line (or lines) of magnetic particles

form(s) across the copper face of the indicator when the magnetic particles are applied simultaneously with the magnetizing force.

When a clearly defined line of particles is not formed, the magnetizing technique shall be changed as needed.

2) Magnetic Field Direction

The direction of magnetization shall be determined by particle indications obtained using an indicator. When a clearly defined line of particles is not formed in the desired direction, the magnetizing technique shall be changed as needed.

4.3 Yoke

1) Magnetizing Procedure

For this technique, only AC yokes shall be used.

2) Lifting Power of Yokes

(1) Prior to use, the magnetizing power of electromagnetic yokes shall have been checked within the past year. The magnetizing power of permanent magnetic yokes shall be checked daily prior to use. The magnetizing power of all yokes shall be checked whenever the yoke has been damaged or repaired.

(2) Each alternating current electromagnetic yoke shall have a lifting power of at least 10 lb (4.5 kg) at the maximum pole spacing that will be used.

(3) Each weight shall be weighed with a scale from a reputable manufacturer and stenciled with the applicable nominal weight prior to first use. A weight need only be verified again if damaged in a manner that could have caused potential loss of material.

4.4 Frequency of Calibration

1) Frequency

Magnetizing equipment with an ammeter shall be calibrated at least once a year, or whenever the equipment has been subjected to major electric repair, periodic overhaul, or damage. If equipment has not been in use for a year or more, calibration shall be done prior to first use.

2) Procedure

The accuracy of the unit's meter shall be verified annually by equipment traceable to a national standard. Comparative readings shall be taken for at least three different current output levels encompassing the usable range.

3) Tolerance

The unit' s meter reading shall not deviate by more than ±10% of full scale, relative to the actual current value as shown by the test meter.

4) Light Meters

Light meters shall be calibrated at least once a year or whenever the meter has been repaired. If meters have not been in use for one year or more, calibration shall be done before being used.

5. General Requirements

5.1 Surface Conditioning

1) Satisfactory results are usually obtained when the surfaces are in the as-welded, as-rolled, as-cast, or as-forged conditions. However, surface preparation by grinding or machining may be necessary where surface irregularities could mask indications due to discontinuities.

2) Prior to magnetic particle examination, the surface to be examined and all adjacent areas within at least 1 in. (25 mm) shall be dry and free of all dirt, grease, lint, scale, welding flux and spatter, oil, or other extraneous matter that could interfere with the examination.

3) Cleaning may be accomplished using detergents, organic solvents, descaling solutions, paint removers, vapor degreasing, sand or grit blasting, or ultrasonic cleaning methods.

4) If nonmagnetic coatings are left on the part in the area being examined, it shall be demonstrated that indications can be detected through the existing maximum coating thickness applied. When AC yoke technique is used, the demonstration shall be in accordance with Mandatory Appendix Ⅰ of ASME Section V Article 7. In this procedure, if the materials or weldments are coated by nonmagnetic coatings. The coatings shall be removed by appropriate method thoroughly and then the examination shall be applied.

5) When nonmagnetic coatings are applied temporarily to uncoated surfaces only in amounts sufficient to enhance particle contrast, it shall be demonstrated that indications can be detected through the enhancement coating.

5.2 Nonmagnetic Surface Contrast Enhancement

Nonmagnetic surface contrasts may be applied by the examiner to uncoated surfaces, only in amounts sufficient to enhance particle contrast. When nonmagnetic surfaces contrast enhancement is used, it shall be demonstrated that indications can be detected through the enhancement. Thickness measurement of this nonmagnetic surface contrast enhancement is not required.

5.3 Techniques and Materials

The ferromagnetic particles used as an examination medium shall be wet, and may be nonfluorescent. Yoke magnetization techniques shall be used.

6. Examination

6.1 Preliminary Examination

Before the magnetic particle examination is conducted, a check of the examination surface shall be conducted to locate any discontinuity surface openings which may not attract and hold magnetic particles because of their width.

6.2 Direction of Magnetization

At least two separate examinations shall be performed on each area. During the second examination, the lines of magnetic flux shall be approximately perpendicular to those used during the first examination. A different technique for magnetization may be used for the second examination.

6.3 Method of Examination

The magnetizing current shall be turned on after the particles have been applied. Flow of particles shall stop with the application of current. Wet particles applied from aerosol spray cans may be applied before and/or after magnetizing current is applied. Wet particles may be applied during the application of magnetizing current if they are not applied directly to the examination area and are allowed to flow over the examination area or are applied directly to the examination area with low velocities insufficient to remove accumulated particles.

6.4 Examination Coverage

All examination shall be conducted with sufficient field overlap to ensure 100% coverage at the required sensitivity.

6.5 Yoke Technique

This method shall only be applied to detect discontinuities that are open to the surface of the part. For this technique alternating or direct current electromagnetic yokes shall be used. Sequences of examination are as follows:

1) Position the yoke on the surface to be examined
2) Switch on the magnetization current.
3) Apply the magnetic particles in a light, uniform, dust like coating over the area of interest while the yoke remains on. An applicator may be used for rapid and uniform application of wet particle.
4) Switch off magnetizing current and remove yoke from the part.
5) Demagnetize components or materials after completion of the examination when required, as specified in paragraph.
6) Examinations shell be conducted with sufficient overlap to assure 100 percent coverage at the established test sensitivity.
7) The preferred distance between successive yoke location shall overlap by a minimum of 1-1/2 in.

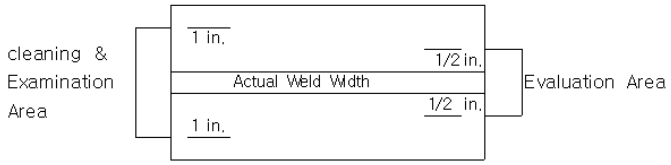
8) At least two separate examinations shall be carried out on magnetic flux perpendicular to those used for the first examination in that area.

9) All surfaces shall be cleaned of magnetic particles after testing as completed.

10) The continuous method shall be used.

6.6 Examination Area

A accessible surface of the actual weld width plus at least 1 in.(25 ㎜) on each side adjacent to the weld shall be cleaned and examined. Actual weld width and the heat affected zone of the base metal for at least 1T or 1/2 in. (13 ㎜) minimum on each side adjacent to the weld shall be evaluated.



Examination Area for Weld

6.7 Excess Particle Removal

Accumulations of excess particles in examinations shall be removed with a light air stream from a bulb or syringe or other source of low pressure dry air. The examination current or power shall be maintained while removing the excess particles.

6.8 Demagnetization

When residual magnetism in the part could interfere with subsequent processing or usage, the part shall be demagnetized any time after completion of the examination. In general, demagnetization is accomplished by subjecting the part to a field equal to or greater than that used to magnetize the part, then continuously reversing the field direction while gradually decreasing it to zero. The effectiveness of the demagnetizing operation can be indicated by the use of appropriate magnetic field indicators or field strength meters.

1) Demagnetizing with Yokes

Alternating current yokes may be used for local demagnetization by placing the poles on the surface, moving them around the area, and slowly with drawing the yoke while it is still energized.

2) Reversing Direct Current

The part to be demagnetized is subjected to consecutive steps of reversed and reduced direct current magnetization to a desired level. (This is the most effective process of demagnetizing large parts in which the alternating current field has insufficient penetration to remove the

internal residual magnetization.) This technique requires special equipment for reversing the current while simultaneously reducing it in small increments.

6.9 Post Examination cleaning

When post-examination cleaning is required by the procedure, it should be conducted as soon as practical using a process that does not adversely affect the part. Post-test cleaning is necessary where magnetic particle materials could interfere with subsequent processing or with service requirements. The purchaser should specify when post-test cleaning is needed and the extent required. Typical post-cleaning techniques employed are:

(a) the use of compressed air to blow off unwanted dry magnetic particles;

(b) drying of wet particles and subsequent removal by brushing or with compressed air;

(c) removal of wet particles by flushing with solvent;

(d) other suitable post-test cleaning techniques may be used if they will not interfere with subsequent requirements.

7.0 Interpretation and Evaluation

The interpretation shall identify if an indication as false, nonrelevant or relevant. False and nonrelevant indications shall be proven as false or nonrelevant. Interpretation shall be carried out to identify the locations of indications and the character of the indication.

7.1 Visible (Color Contrast) Magnetic Particles

Surface discontinuities are indicated by accumulations of magnetic particles which should contrast with the examination surface. The color of the magnetic particles shall be sufficiently different than the color of the examination surface. A minimum light intensity of 100 fc (1000 lx) is required on the surface to be examined to ensure adequate sensitivity during the examination and evaluation of indications. The light source, technique used. and light level verification is required to be demonstrated one time, documented, and maintained on file.

7.2 Fluorescent Magnetic Particles.

With fluorescent magnetic particles, the process is essentially the same as in 7.1, with the exception that the examination is performed using an ultraviolet light, called *black light.*

The examination shall be performed as follows:

(a) It shall be performed in a darkened area.

(b) Examiners shall be in a darkened area for at least 5 min prior to performing examinations to enable their eyes to adapt to dark viewing. Glasses or lenses worn by examiners shall not be photosensitive.

(c) Black lights shall achieve a minimum of 1000_W/cm2 on the surface of the part being examined

throughout the examination.

(d) Reflectors and filters should be checked and, if necessary, cleaned prior to use. Cracked or broken filters shall be replaced immediately.

(e) The black light intensity shall be measured with a black light meter prior to use, whenever the light's power source is interrupted or changed, and at the completion of the examination or series of examinations.

7.3 All indications shall be evaluated in terms of the acceptance standards of the referencing code section.

7.4 Discontinuities on or near the surface are indicated by retention of the examination medium. However, localized surface irregularities due to machining marks or other surface conditions may produce false indications.

7.5 Broad areas of particle accumulation, which might mask indications from discontinuities, are prohibited, and such areas shall be cleaned and reexamined.

7.6 Valid Indications

All valid indications formed by magnetic particle examination are the result of magnetic leakage fields. Indications may be relevant, non-relevant, or false.

1) Relevant Indications

Relevant indications are produced by leakage fields which are the results of discontinuities. Relevant indications require evaluation with regard to the acceptance standards agreed upon between the manufacturer and the purchaser.

2) Nonrelevant Indications

Nonrelevant indications can occur singly or in patterns as a result of leakage fields created by conditions that require no evaluation such as changes in section (like keyways and drilled holes). inherent material properties (like the edge of a bimetallic weld), magnetic writing, etc.

3) False Indications

False indications are not the result of magnetic forces. Examples are particles held mechanically or by gravity in shallow depressions or particles held by rust or scale on the Surface.

8. Acceptance Standards

8.1 ASME Section Ⅷ Div. 1 Appendix 6 & Div.2(Article 9-1) (For Weld) and ASME Section Ⅰ Appendix A-260

1) Evaluation of Indications

Indications will be revealed by retention of magnetic particles. All such indications are not necessarily imperfections, however, since excessive surface roughness, magnetic permeability variations (such as at the edge of heat affected zones). etc., may produce similar indications.

An indication of an imperfection may be larger than the imperfection that cause it; however, the size of the indication is the basis for acceptance evaluation. Only indications which have any dimension greater than 1/16 in. (1.5 ㎜) shall be considered relevant.

(1) A linear Indication is one having a length greater than three times the width.

(2) A rounded indication is one of circular or elliptical shape with the length equal to or less than three times the width.

(3) Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant.

2) Acceptance Standards

All surfaces to be examined shall be free of:

(1) relevant linear indications;

(2) relevant rounded indications greater than 3/16 in. (5.0 ㎜); and

(3) four or more relevant rounded indications in a line separated by 1/16 in. (1.5 ㎜) or less (edge to edge);

8.2 ASME B31.1, Chapter Ⅵ

The following relevant indications are unacceptable:

1) any cracks or linear indications;

2) rounded indications with dimensions greater than 3/16 in. (5.0 ㎜);

3) four or more rounded indications in a line separated by 1/16 in.(2.0 ㎜) or less edge to edge ;

4) ten or more rounded indications in any 6 sq. in. (3,870 ㎟) of surface with the major dimension of this area not to exceed 6 in. (150 ㎜) with the area taken in the most unfavorable location relative to the indications being evaluated.

8.3 ASME Sec. Ⅷ, Div. 1, Appendix 7 (For Castings)

Surface indications determined by magnetic particle examination shall be compared with those photographs in ASTM E 125, Standard Reference Photographs for Magnetic Particle Indications on Ferrous castings, and shall be removed if they exceed the following limits:

Type	Degree
Ⅰ. Linear discontinuities (hot tears and cracks)	All
Ⅱ. Shrinkage	2
Ⅲ. Inclusions	3
Ⅳ. Chills and chaplets	1
Ⅴ. Porosity	1

8.4 ASME SEC Div.2 paragraph 7.5.6

Unacceptable indications shall be removed or reduced to an indication of acceptable size. Whenever an indications shall be removed or removed by chipping or grinding and subaequent repair by welding in not required, the excavated area shall be blended into the surrounding surface so as to avoid notches, crevices, or corners. Where welding is required after removal of indications, the repair shall be done in accordance with paragraph 6.2.7.

1) All surfaces to be examined shall be free of:
   (a) Relevant linear indications
   (b) Relevant rounded indications greater than 5mm(3/16in)
   (c) Four or more relevant rounded indications in a line separated by 1.5mm(1/16in) or less, edge-to-edge
2) Crack like indications detected, irrespective of surface conditions, are unacceptable.

9. Documentation

9.1 Recording of Indications

1) Nonrejectable Indications

Nonrejectable indications shall be recorded as specified by the referencing Code Section.

2) Rejectable Indications

Rejectable indications shall be recorded. As a minimum, the type of indications (linear or rounded), location and extent (length or diameter or aligned) shall be recorded.

9.2 Means of Recording

When required by a contract, permanent records of the location, type, direction, lengths, and spacings of indications may be made by one or more of the following means.

1) Sketches

Sketching the indications and their locations.

2) Photographing

Photographing the indications themselves, the tape, or the strippable film reproductions of the indications.

3) Written Records

Recording the location, length, orientation, and number of the indications.

9.3 Examination Records

For each examination, the following information shall be recorded:

1) procedure identification and revision;
2) magnetic particle equipment and type of current;
3) magnetic particles (visible or fluorescent, wet);

4) examination personnel identity and if required by referencing Code Section, qualification level;

5) map or record of indications per 9.1 above;

6) material and thickness;

7) lighting equipment; and

8) date of examination.

9.4 Performance Demonstration

Performance demonstration, when required by the referencing Code Section, shall be documented .

9.5 The report shall be signed and dated by the qualified and certified Level Ⅱ who examined the evaluation and disposition of the materials or welds and approved by the qualified and certified Level Ⅱ or Level Ⅲ who performed the final acceptance of the results.

9.6 An examination report shall be prepared and furnished to the client. Report of Magnetic Particle Examination will be used unless otherwise specified by client.

10. Appendix

Appendix Ⅰ : Procedure Qualification for Essential/Nonessential variable

Appendix Ⅱ : Report of Magnetic Particle Examination - 2 sheets

Table 1. Requirement of a Magnetic Particle Examination Procedure

Requirement	Essential Variable	Nonessential Variable	Paragraph No
Magnetizing Technique	X		1.1
Magnetizing current type or amperage outside range specified by this article or as previously qualified	X		4.3
Surface preparation	X		5.1
Magnetic particles (fluorescent/visible, color, particle size, wet/dry)	X		4.1
Method of particle application	X		6.3
Method of excess particle removal	X		6.7
Minimum light intensity	X		7.1
Existing Coatings, greater than the thickness demonstrated	X		5.1 4)
Nonmagnetic surface contrast enhancement , when utilized	X		5.2
Performance demonstration, when required	X		9.4
Examination part surface temperature outside of the temperature range recommended by the manufacture of the particles or as previously	X		4.1 2)
Shape or size of the examination object		X	1.3
Equipment of the same type		X	4.3
Temperature (within those specified by manufacturer or as previously qualified)		X	4.1 2)
Demagnetizing technique		X	6.8
Post examination cleaning technique		X	6.9
Personnel qualification requirements		X	3.2

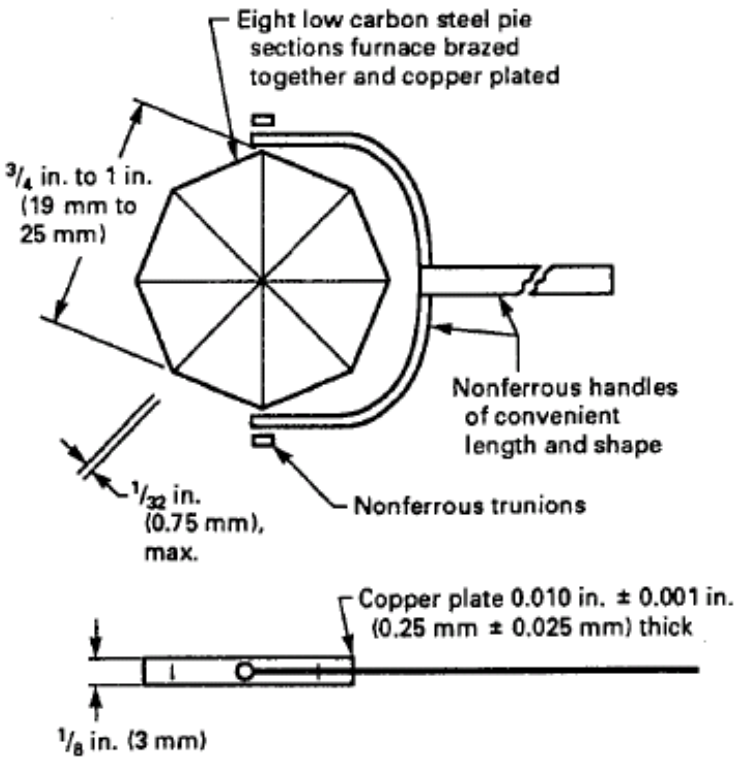


Fig. 1. Pie-Shaped magnetic particle field indicator

Appendix. Ⅰ

Procedure Qualification for Essential/Nonessential variable

Essential variable		Ferrous material
1	Magnetizing technique	AC YOKE TYPE
2	Magnetizing current type or amperage outside range specified by this article or as previously qualified.	ALTERNATING CURRENT (2.1 ~ 2.6Amps)
3	Surface preparation	AS GROUND AFTER WELDED AS ROLLED AS FORGED(AS MACHINED)
4	Magnetic particles (fluorescent/visible, color, particle size, wet/dry)	In accordance with para 4.1 in this Procedure
5	Method of particle application	CONTINUOUS METHOD
6	Method of excess particle removal	A GENTLE AIR STREAM WHILE THE YOKE REMAINS ON THE TEST MATERIALS.
7	Minimum light intensity	MINIMUM 100 fc (1000 lx)
8	Existing Coatings, greater than the thickness demonstrated	NONCOATING
9	Nonmagnetic surface contrast enhancement, when utilized	WHITE PAINT
10	Performance demonstration, when required	DEMONSTRATION, WHEN REQUIRED
11	Examination part surface temperature outside of the temperature range recommended by the manufacturer of the particles or as previously qualified	Wet type : No exceed 135°F

Procedure Qualification for Essential/Nonessential variable

Nonessential variable		Ferrous material
1	Shape or size of the examination object	
2	Equipment of the same type.	
3	Temperature(within those specified by manufacturer or as previously qualified)	
4	Demagnetizing technique	
5	Post examination cleaning technique	
6	Personnel qualification requirements	ASNT / SNT-TC-1A

Appendix Ⅱ : Report of Magnetic Particle Examination - A

자 분 탐 상 검 사 보 고 서
REPORT OF MAGNETIC PARTICLE EXAMINATION

SUNG JIN GEOTEC CO., LTD
#20-1,SUNG AM-DONG,NAM-KU,ULSAN,KOREA
TEL:(052)228-5801~4,FAX(052)228-5989

Report No. 보고서번호	
Page No. 페이지번호	

Project Name 공사명	Owner / Customer 주문주/고객	Job No. 공사번호
Item Name / 제품명	Item No / 제품 번호	Drawing No. 도면번호 Rev No.
Material/ 재질	Surface Condition 표면조건	Testblock 시험편
	☐ AS-Machined ☐ AS-Ground	☐ Field Indicator
	☐ AS-Welded.	☐ Lifting Block

Equipment	Magnetization Technique 자 화 방 법	Direction of Magnetic Field 자 장 방 향	Magnetic particles 자 분	Black Light 자외선등
☐ AC ☐ DC BRAND : MODEL : OUTPUT : CURRENT : SPACING : cm	☐ YOKE ☐ PROD ☐ COIL	☐ LONGITUDINAL ☐ CIRCULAR ☐ BOTH	BRAND : MODEL : ☐ DRY ☐ WET ☐ COLOR	BRAND : MODEL NO : INTENSITY : μ w/㎠ WAVELENGTH :
				Demagnetization 탈 자
				☐ YES ☐ NO

Acceptance Standard & Applicable procedures / 합격기준 및 적용절차서

★ Inspection Stage 검사시기

A : After Final Weld
A/P : After P.W.H.T
B/P : Before P.W.H.T
A/H : After Hydrotest
A/F : After Forming
A/M : After Machining
B : Bevel angle face

R : Root Layer
EP : Edge Preparation
ABG : After Back Gouging
TAR : Temporary Attachment Removed
RG : Repair Groove

★★ Interpretation 결함약호

NSD : Non Significant Defect
C. C : Crater Crack
E. C : Edge Crack
L. C : Longi Crack
T. C : Transverse Crack
L. C : Lamination Crack

O. L : Over Lap
G. P : Gas Pore
L. P : lack of Penet
L. F : Lack of fusion
I. N : Inclusion (Slag)
U. C : Under Cut

☐ SKETCH ON DOT LINE, IF NECESSARY OR ☐ ATTACHED. 필요시 점선안에 스케치하거나 또는 첨부할 것

Sketch

Identification No. 확 인 번 호	★ Stage	Test Results Grade	Acc	Rej	★★ Interpretation	Welder No. 용접사 번호	Remark 비 고

NDT.Co Operator (Level II)	Witnessed by QC (Level II)	Approved.By LEVEL III	Reviewed by Client	Reviewed by AI

Appendix II : Report of Magnetic Particle Examination - B

자 분 탐 상 검 사 보 고 서
REPORT OF MAGNETIC PARTICLE EXAMINATION

SUNG JIN GEOTEC CO., LTD
#20-1,SUNG AM-DONG,NAM-KU,ULSAN,KOREA
TEL:(052)228-5801~4,FAX(052)228-5989

Report No. 보고서번호	
Page No. 페이지번호	

★ Inspection Stage 검사시기 ★★ Interpretation 결함약호

A : After Final Weld A/P : After P.W.H.T B/P : Before P.W.H.T A/H : After Hydrotest A/F : After Forming A/M : After Machining B : Bevel angle face	R : Root Layer EP : Edge Preparation ABG : After Back Gouging TAR : Temporary Attachment Removed RG : Repair Groove	NSD : Non Significant Defect C. C : Crater Crack E. C : Edge Crack L. C : Longi Crack T. C : Transverse Crack L. C : Lamination Crack	O. L : Over Lap G. P : Gas Pore L. P : lack of Penet L. F : Lack of fusion I. N : Inclusion (Slag) U. C : Under Cut

Identification No. 확 인 번 호	★ Stage	Test Results				Welder No. 용접사 번호	Remark 비 고
		Grade	Acc	Rej	★★ Interpretation		

Ⅳ. Liquid Penetrant Examination Procedure

TABLE OF CONTENTS

1. Scope

1.1 This procedure describes the minimum requirements for liquid penetrant examination of materials and welds in accordance with the requirements of ASME Section V Article 6.

1.2 This procedure describes the general requirements for safety materials, equipment, personnel, technique, and acceptance criteria. When differences exist between this procedure and technical specification, the technical specification shall govern.

1.3 The material (austenitic stainless steel, nickel base alloy, titanium, aluminum, etc.), shapes, or size to be examined, and the extent of examination shall be in accordance with manufacturing drawing. Liquid penetrant examination using the solvent removable technique for detecting discontinuities to be found on base materials, weldments, weld edge preparation, forging and bar etc. of which the components and parts are manufactured with carbon steel and nonferrous materials for boilers, heat exchangers and pressure vessels.

2. References

2.1 ASME Sec. Ⅰ Power Boilers (2007 Edition)

2.2 ASME Sec. V Nondestructive Examination (2007 Edition-2009ADD)

2.3 ASME Sec. Ⅷ Div.1 & Div.2 Rules for construction of Pressure Vessels (2007 Edition-2009ADD)

2.4 ASME B31.1 Power Piping (2007 Edition-2009ADD)

2.5 ASME Sec. Ⅸ Welding and Brazing Qualification (2007 Edition-2009ADD)

2.6 ASNT Recommended Practice No. SNT-TC-1A for NDT Personnel Qualification and Certification (2006 Ed.)

3. General Requirements

3.1 Procedure Qualification

This procedure shall be qualified before use according to the table 1, using the "Procedure Qualification for Essential/Nonessential variable".

3.2 Personnel Qualification

1) Personnel shall be qualified and certified in accordance with the employer written practice that shall meet SNT-TC-1A.

2) Only qualified and certified Level Ⅱ or Level Ⅲ Personnel shall make determinations to the acceptability of examination results.

3.3 Procedure Requirements

1) Liquid penetrant examination shall be performed in accordance with a written procedure which shall as a minimum, contain the requirements listed in Table 1. The written procedure shall establish a single value, or range of values, for each requirement. If required any additional written procedures will need to be submitted to the Purchaser’s inspector for review prior to use.

2) When procedure qualification is specified, a change of requirement in Table 1 identified an essential variable from the specified value, or range of values, shall require re-qualification of the written procedure. A change of a requirement identified as a nonessential variable from the specified value, or range of values, does not require re-qualification of the written procedure. All changes of essential or nonessential variables from the value, or range of values, specified by the written procedure shall require revision of, or an addendum to, the written procedure.

3.4 Surface Preparation

1) In general, satisfactory results may be obtained when the surface of the part is in the as-welded, as-rolled, as-cast, or as-forged condition. Surface preparation by grinding, machining or other methods may be necessary where surface irregularities could mask indications.

2) Prior to each liquid penetrant examination, the surface to be examined and all adjacent areas within at least 1 in. (25 mm) shall be dry and free of all dirt, grease, lint, scale, welding flux, weld spatter, paint, oil, and other extraneous matter that could obscure surface openings or otherwise interfere with the examination.

3) Solvent spray type may be used for surface cleaning. Cleaning solvents shall meet the requirements of 6.1 in this procedure. The cleaning method employed is an important part of the examination process.

3.5 Drying after Preparation

After cleaning, drying of the surfaces to be examined shall be accomplished by normal evaporation or with forced hot or cold air. A minimum period of time shall be established to ensure that the cleaning solution has evaporated prior to application of the penetrant. In this procedure, allowable drying time for the surface to dry shall be at least 1 min. before applying penetrant.

3.6 Technique

Color contrast (visible under white light) penetrant shall be used with the solvent removable process.

3.7 Technique for Standard Temperatures

As a standard technique, the temperature of the penetrant and the surface of the part to be processed shall not be below 50°F (10℃) nor above 125°F (52 ℃) throughout the examination period. Local heating or cooling is permitted provided the part temperature remains in the range of 50°F to 125°F (10℃ to 52℃) during the examination. Where it is not practical to comply with these temperature limitations, other temperatures and times may be used, provided the procedures are qualified as specified in 6.2.

3.8 Specification Requrirements

1) General Requirements

1.1) Magnetic particle and liquid penetrant examination shall be made in the followingloca tions:

a) Plate edges greater than 50 mm in thickness, prior to welding, for detection of laminations

or cracks. Plate edge laminations shall not exceed 12 mm in length. Cracks are not permitted and shall be repaired.

b) All back-chipped or gouged surfaces prepared for second-side welding.

c) For Division 1 construction, the surfaces of all welds joining heavily loaded attachments to the vessel internal or external surface, e.g., vessel support rings, lugs or saddles, brackets, and rings supporting internal catalyst bed gratings.

d) For Division 2 construction, the surfaces of all permanent attachment welds, such as internally or externally attached lugs, rings, brackets, supports, or clips.

e) The inside and outside surfaces of all seams and nozzle attachment welds.

f) Built-up weld deposits in Division 2 construction shall have the first weld layer and the completed weld build-up surface, together with all adjacent base metal surfaces within 50 mm of the build-up examined.

g) The surface of all weld repairs. All repairs shall be made by a procedure that has been approved by the CONTRACTOR.

2) All fully overlayed surfaces and clad restoration seams shall be subject to complete visual examination. Additionally, all weld overlayed surfaces shall be inspected by liquid penetrant, in accordance with ASTM E165 and applicable code. This shall be carried out after any post weld heat treatment. All overlayed surfaces that are subsequently machined shall be examined after final machining.

The acceptance criteria shall be as follows:

• All weld overlayed surfaces shall be free from cracks and fissure defects.

• Any single circular defect shall not exceed 1.5 mm in diameter.

• The sum of the diameters in any 90 mm circle shall not exceed 4 mm, or the minimum specified depth of the overlay, whichever is greater.

Liquid penetrant materials used for non-destructive examinations shall be free from organic and inorganic chlorides. When used on nickel alloys the penetrant materials shall also be sulphur free.

3) All weld overlay and clad restored weld surfaces, as well as attachments to those surfaces, shall be 100 percent examined by liquid penetrant examination. Examination shall be performed after PWHT when PWHT is performed. Surfaces examined shall be free of cracks, lack of fusion, porosity and other defects which would reduce the effectiveness of the overlay.

4) All attachment fillet welds to the pressure parts shall be ground smooth and radiussed and 100% magnetic particle and liquid penetrant examination carried out.

5) After removal of temporary lugs, erection cleats and other fit-up attachments, any remaining weld metal protuberance shall be ground flush with the surface of the part, and the area shall be inspected for cracks using liquid penetrant or magnetic particle testing.

4. Equipment and Materials

4.1 Penetrant Apparatus

Compressed-air-type apparatus, or paint brushes may be used to apply the materials. (paint brush shall not be used to apply remover or developer).

4.2 Materials

The following material shall be used for examination. For the examination of nickel base alloys, austenitic stainless steels, and titanium, the residual total halogen and sulfur content be in accordance with 6.1 in this procedure. The manufacturer shall provide materials with a certificate of material analysis to the SGT's Requalification may be required when any change or substitution in type or family group of penetrant materials including removers, penetrants and developers.

Material	Type	Manufacturer
Penetrant	NPP2	NAWOO
	PA	GS CHEM
	P2	KYUNG-DO
Remover	NPR1-3	NAWOO
	RA	GS CHEM
	R1-3	KYUNG-DO
Developer	NPD4	NAWOO
	DA	GS CHEM
	D4	KYUNG-DO

4.3 Calibration

Light meters shall be calibrated at least once a year or whenever the meter has been repaired. If meters have not been in use for one year or more, calibration shall be done before being used.

5. Examination

5.1 Penetrant Application

If the penetrant is applied by spraying using compressed-air-type apparatus, filters shall be placed on the upstream side near the air inlet to preclude contamination of the penetrant by oil, water, dirt, or sediment that may have collected in the lines.

5.2 Penetration (Dwell) Time

After application, allow excess penetrant to drain. from the part, while allowing for proper penetrant dwell time. The length of time the penetrant must remain on the part to allow proper penetration should be as recommended by the penetrant manufacturer. Table 2, however, provides a guide for selection of penetrant dwell times for a variety of materials, forms. and types of discontinuity. Unless otherwise specified, the dwell time shall not exceed the maximum

recommended by the manufacturer. Penetration (dwell) time is critical. The minimum penetration time shall be as required in Table 2 or as qualified by demonstration for specific applications.

5.3 Excess Penetrant Removal

After the specified penetration (dwell) time has elapsed, any penetrant remaining on the surface shall be removed, taking care to minimize removal of penetrant from discontinuities. Excess solvent removable penetrants shall be removed by wiping with a cloth or absorbent paper, repeating the operation until most traces of penetrant have been removed. The remaining traces shall be removed by lightly wiping the surface with cloth or absorbent paper moistened with solvent. To minimize removal of penetrant from discontinuities, care shall be taken to avoid the use of excess solvent. If the wiping step is not effective, as evidenced by difficulty in removing the excess penetrant reapply the penetrant for the prescribed dwell time. Fushing the surface with solvent, following the application of the penetrant and prior to developing, is prohibited.

5.4 Drying After Excess Penetrant Removal

Following the removal of excess surface penetrant by solvent wipe-off technique, the surfaces may be dried by natural evaporation, blotting or wiping for minimum 1 minutes/maximum 30 minutes.

5.5 Developing

The developer shall be applied as soon as possible after penetration removal;

The time interval shall not exceed 30 minutes. Insufficient coating thickness may not draw the penetrant out of discontinuities; conversely, excessive coating thickness may mask indications. With color contrast penetrants, only a wet developer shall be used. Prior to applying suspension type wet developer to the surface, the developer must be thoroughly agitated to ensure adequate dispersion of suspended particles.

1) Dry Developer Application.

Dry developer shall be applied only to a dry surface by a soft brush, hand powder bulb, powder gun, or other means, provided the powder is dusted evenly over the entire surface being examined.

2) Aqueous Developer Application

Aqueous developer may be applied to either a wet or dry surface. It shall be applied by dipping, brushing, spraying, or other means, provided a thin coating is obtained over the entire surface being examined. Drying time may be decreased by using warm air, provided the surface temperature of the part is not raised above 125°F(52℃). Blotting is not permitted.

3) Developing time for final interpretation begins immediately after the application of a dry developer or as soon as a wet developer coating is dry. The minimum developing time shall be as required by Table 2. The length of time the developer is to remain on the part prior to examination should be not less than 10 min. The maximum permitted developing times are 60 min. for any types of developers.

5.6 Interpretation

1) The true size and type of discontinuities are difficult to evaluate if the penetrant diffuses excessively into the developer. Consequently, the surface shall be closely observed during the application of the developer to monitor the behavior of indications which tend to bleed-out profusely.

2) Final Interpretation

Final interpretation shall be made within 10 to 60 min after the requirements of 5.5 2) are satisfied. If bleed-out does not alter the examination results, longer periods are permitted. If the surface to be examined is large enough to preclude complete examination within the prescribed or established time, the examination shall be performed in increments.

3) Characterizing Indications

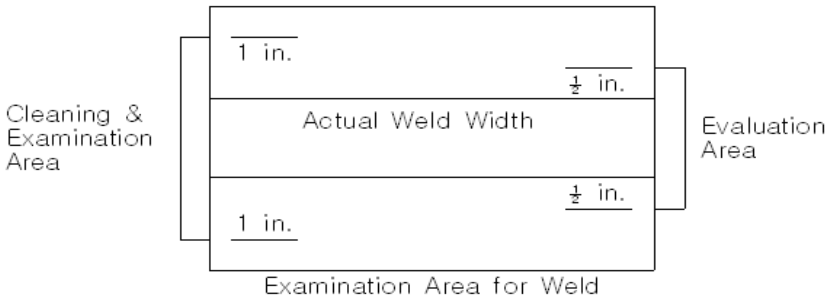
The types of discontinuities are difficult to evaluate if the penetrant diffuses excessively into the developer. If this condition occurs, close observation of the formation of indications during application of the developer may assist in characterizing and determining the extent of the indications.

4) Color Contrast Penetrants.

With a color contrast penetrant, the developer forms a reasonably uniform white coating. Surface discontinuities are indicated by bleed-out of the penetrant which is normally a deep red color that stains the developer. Indications with a light pink color may indicate excessive cleaning. Inadequate cleaning may leave an excessive background making interpretation difficult. A minimum light intensity of 100 fc (1000 lx) is required on the surface to be examined to ensure adequate sensitivity during the examination and evaluation of indications. The light source, technique used, and light level verification is required to be demonstrated one time, documented, and maintained on file.

5.7 Examination Area.

All accessible surface of the actual weld width plus at least 1 inch on each side adjacent to the weld shall be cleaned and examined. Actual weld width and the heat-affected zone of the base metal for at least 1T or 1/2 in.(13 ㎜) minimum on each side adjacent to the weld shall be evaluated.



5.8 Post-examination Cleaning

When post-examination cleaning is required by the procedure, it should be conducted as soon as practical after evaluation and documentation using a process that does not adversely affect the part. Post cleaning is necessary in those cases where residual penetrant or developer could interfere with subsequent processing or with service requirement. It is particularly important where residual penetrant examination materials might combine with other factors in service to produce corrosion. A suitable technique, such as a simple water rinse, water spray, machine wash, vapor degreasing, solvent soak, or ultrasonic cleaning may be employed. It is recommended that if developer removal is necessary, it should be carried out as promptly as possible after examination so that it does not “fix”on the part.

6. Special Requirements

6.1 Control of Contaminants

The user of this procedure shall obtain certification of contaminant content for all liquid penetrant materials used on nickel base alloys, austenitic stainless steels, and titanium. These certifications shall include the penetrant manufacturer's batch numbers and the test results obtained in accordance with Article 6, Mandatory Appendix Ⅱ of ASME Section V. These records shall be maintained as required by the referencing Code Section.

1) Nickel Base Alloy

When examination nickel base alloy, all penetrant materials shall be analyzed individually for sulfur content in accordance with SE-165, Annex 4. Alternatively, the material may be decomposed in accordance with SD-129 and analyzed in accordance with SD-516. The sulfur content shall not exceed 1% by weight.

2) Austenitic or Duplex Stainless Steel and Titanium

When examination austenitic or duplex stainless steel and titanium, all penetrant materials shall be analyzed individually for halogens content in accordance with SE-165, Annex 4. Alternatively, the material may be decomposed and analyzed in accordance with SD-808 or SE-165, Annex 2 for chlorine and SE-165, Annex 3 for fluorine. The total halogens content shall not exceed 1% by weight.

6.2 Techniques for Nonstandard Temperatures

1) General

When it is not practical to conduct a liquid penetrant examination within the temperature range of 50°F to 125°F (10℃ to 52℃), the examination procedure at the proposed lower or higher temperature range requires qualification of the penetrant materials and processing. This shall require the use of a quench cracked aluminum block, as a liquid penetrant comparator block.

2) Liquid Penetrant Comparator

A liquid penetrant comparator block shall be made as follows. The liquid penetrant comparator blocks shall be made of aluminum, ASTM B 209, Type 2024, 3/8 in.(9.5 ㎜) thick, and should have approximate face dimensions of 2 in. × 3 in. (52 ㎜ × 76 ㎜). At the center of each face,

an area approximately 1 in. (25 ㎜) in diameter shall be marked with a 950˚F (510℃) temperature, indicating crayon or paint. The marked area shall be heated with a blowtorch, a Bunsen burner, or similar device to a temperature between 950˚F (510℃) and 975˚F (524℃). The specimen shall then be immediately quenched in cold water, which produces a network of fine cracks on each face. The block shall than be dried by heating to approximately 300˚F (149℃). After cooling, the block shall be cut in half. One-half of the specimen shall be designated block “A” and the other block “B” for identification in subsequent processing. Figure 1 illustrates the comparator blocks “A” and “B”, As an alternate to cutting the block in half to make blocks “A” and “B”, separate blocks 2 in. × 3 in. (52 ㎜ × 76 ㎜) can be made using the heating and quenching technique as described above. Two comparator blocks with close|y matched crack patterns may be used. The blocks shall be marked “A” and “B”,

3) Comparator Application

(1) If it is desired to qualify a liquid penetrant examination procedure at a temperature of less than 50˚F (10℃), the proposed procedure shall be applied to block “B” after the block and all materials have been cooled and held at the proposed examination temperature until the comparison is completed. A standard procedure which has previously been demonstrated as suitable for use shall be applied to block “A” in the 50˚F to 125˚F (10℃ to 52℃) temperature range. The indications of cracks shall be compared between blocks “A” and “B”, If the indications obtained under the proposed conditions on block “B” are essentially the same as obtained on block “A” during examination at 50˚F to 125˚F (10℃ to 52 ℃), the proposed procedure shall be considered qualified for use. A procedure qualified at a temperature lower than 50˚F (10℃) shall be qualified from that temperature to 50˚F (10℃).

(2) If the proposed temperature for the examination is above 125˚F (52℃), block “B” shall be held at this temperature throughout the examination. The identifications of cracks shall be compared as described in (1) above while block “B” is at the proposed temperature and block “A” is at the 50˚F to 125˚F (10℃ to 52℃) temperature range. To qualify a procedure for temperatures above 125˚F (52℃), the upper and lower temperature limits shall be established and the procedure qualified at these temperatures.

(3) As an alternate to the requirements of (1) and (2) above, when using color contrast penetrants, it is permissible to use a single comparator block for the standard and nonstandard temperatures and to make the comparison by photography.

(a) When the single comparator block and photographic technique is used, the processing details (as applicable) described in (1) and (2) above apply. The block shall be thoroughly cleaned between the two processing steps. Photographs shall be taken after processing

at the nonstandard temperature and then after processing at the standard temperature. The indication of cracks shall be compared between the two photographs. The same criteria for qualification as (1) above shall apply.

(b) Identical photographic techniques shall be used to make the comparison photographs.

4) The examination procedure at the proposed lower temperature range requires qualification. Table 3 provides guide for selection of penetration dwell time in the lower range of the nonstandard temperatures.

5) In case of following examination conditions, the procedure shall be qualified before use. The procedure shall meets the requirements listed in Table 1 and shall establish a singe value, or range of values, for each requirement.

(a) decrease in penetrant dwell time

(b) increase in developer dwell time (interpretation time)

7. Evaluation

7.1 All indications shall be evaluated in terms of the acceptance standards of the referencing Code section.

7.2 Discontinuities at the surface will be indicated by bleed-out of penetrant; however, localized surface irregularities due to machining marks or other surface conditions may produce false indication.

7.3 Broad areas of fluorescence or pigmentation which could mask indications of discontinuities are unacceptable, and such areas shall be cleaned and reexamined.

8. Acceptance Standards

8.1 ASME Section Ⅰ Appendix A-270, ASME Section Ⅷ Div. 1 Appendix 8 Div.2 Article 9-2 (For Weld) and ASME Section Ⅸ QW 195

1) Evaluation of Indications.

An indication of an imperfection may be larger than the imperfection that cause it; however, the size of the indication is the basis for acceptance evaluation. Only indications which have any dimension greater than 1/16 in. (1.5 ㎜) shall be considered relevant.

(1) A linear Indication is one having a length greater than three times the width.

(2) A rounded indication is one of circular or elliptical shape with the length equal to or less than three times the width.

(3) Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant.

2) Acceptance Standards.

All surfaces to be examined shall be free of:

(1) relevant linear indications;

(2) relevant rounded indications greater than 3/16 in. (5.0 ㎜); and

(3) four or more relevant rounded indications in a line separated by 1/16 in. (1.5 ㎜) or less (edge to edge);

8.2 ASME B31.1, Chapter Ⅵ

Indications whose major dimensions are greater than 1/16 in. (2.0 ㎜) shall be considered relevant. The following relevant indications are unacceptable:

1) any cracks or linear indications;

2) rounded indications with dimensions greater than 3/16 in. (5.0 ㎜);

3) four or more rounded indications in a line separated by 1/16 in. (2.0 ㎜) or less edge to edge ;

4) Ten or more rounded indications in any 6 sq. in. (3,870 ㎟) of surface with the major dimension of this area not to exceed 6 in. (150 ㎜) with the area taken in the most unfavorable location relative to the indications being evaluated.

8.3 ASME Sec. Ⅷ, Div. 1, Appendix 7 (For Castings)

1) Surface indications determined by liquid penetrant examination are unacceptable if they exceed the following limits:

(1) all cracks and hot tears;

(2) any group of more than six linear indications other than those in (1) above in any rectangular area of 1-1/2 in. × 6 in. (38 ㎜ × 152 ㎜) or less or any circular area having a diameter of 3-1/2 in. (89 ㎜) or less, these areas being taken in the most unfavorable location relative to the indications being evaluated;

(3) other linear indications more than 1/4 in. (6 ㎜) long for thicknesses up to 3/4 in. (19 ㎜) inclusive, more than one-third of the thickness in length for thicknesses from 3/4 in. to 2-1/4 in. (19 ㎜ to 57 ㎜), and more than 3/4 in. (19 ㎜) long for thicknesses over 2-1/4 in. (57 ㎜) (aligned acceptable imperfections separated from one another by a distance equal to the length of the longer imperfection are acceptable);

(4) all indications of nonlinear imperfections which have any dimension exceeding 3/16 in.(5 ㎜).

8.4 ASME SEC VIII Div.2 paragraph 7.5.2

1) unacceptable indications shall be removed or recuced to an indication of acceptable size

. Whenever an indication is removed by chipping or grinding and subsequent repair by welding is not reqruied,cervices, or corners.

(1) All surfaces to be examined shall be free of:

i) Relevant linear indications

ii) Relevant rounded indications greater than 5mm(3/16in)

iii) Four or more relevant rounded indications in a line separated by 1.5mm(1/16in) or less, edge-to-edge

(2) Creck like indications detected, irrespective of surface conditions, are unacceptable

9. Documentation

9.1 Recording of Indications

1) Nonrejectable Indications

Nonrejectable indications shall be recorded as specified by the referencing Code Section.

2) Rejectable indications

Rejectable indications shall be recorded. As a minimum, the type of indications (linear or rounded), location and extent (length or diameter or aligned) shall be recorded.

9.2 Examination Records

For each examination, the following information shall be recorded:

1) procedure identification and revision;

2) liquid penetrant type (visible or fluorescent);

3) type (number or letter designation) of each penetrant, penetrant remover, emulsifier, and developer used);

4) examination personnel identity and if required by referencing Code Section, qualification level;

5) map or record of indications per 9.1 above;

6) material and thickness;

7) lighting equipment; and

8) date of examination.

9.3 Performance Demonstration

Performance demonstration, when required by the referencing Code Section, shall be documented.

9.4 The report shall be signed and dated by the qualified and certified Level Ⅱ who examined the evaluation and disposition of the materials or welds and approved by the qualified and certified Level Ⅱ or Level Ⅲ who performed the final acceptance of the results.

9.5 An examination report shall be prepared and furnished to the client. Report of Liquid Penetrant Examination will be used unless otherwise specified by client.

10.0 Appendix

Appendix Ⅰ : Procedure Qualification for Essential/Nonessential variable

Appendix Ⅱ : Report of Liquid Penetrant Examination - 2 sheets

Table 1. Requirement of a Liquid Penetrant Examination Procedure

Requirement	Essential Variable	Nonessential Variable	Paragraph No
Identification and any change in type or family group of penetrant materials including developers, emulsifiers, etc.)	X		4.2
Surface preparation (finishing and cleaning, including type of cleaning solvent)	X		3.4
Method of applying penetrant	X		5.1
Method of removing excess surface penetrant	X		5.3
Hydrophilic or lipophilic emulsifier concentration and dwell time in dip tanks and agitation time for hydrophilic emulsifiers	X		N/A
Hydrophilic emulsifier concentration in spray application	X		N/A
Method of applying developer	X		5.5
Minimum and maximum time periods between steps and drying aids	X		3.5&5.4& 5.5
Decrease in penetrant dwell time	X		6.2 5)
Increase in developer dwell time (Interpretation Time)	X		6.2 5)
Minimum light intensity	X		5.6 4)
Surface temperature outside 50 to 125°F (10 to 52℃)	X		6.2
Performance demonstration, when required	X		9.3
Personnel qualification requirements		X	3.2
Materials, shapes, or sizes to be examined and the extent of examination		X	1.3&5.7
Post examination cleaning technique		X	5.8

Table 2. Minimum Dwell Times

Material	Form	Type of Discontinuity	Dwell Times (Note 1)	
			Penetrant	Developer
Aluminum, magnesium, steel, brass and bronze, titanium and high temperature alloys	Casting and Welds	Cold shuts, porosity, lack of fusion, cracks (all form)	5 min	10 min
	Wrought materials extrusion, forgings, plate	Laps, cracks (all form)	10 min	10 min
Carbide-tipped tools		Lack of fusion, porosity, cracks	5 min	10 min

Note : (1) For temperature range from 50°F to 125°F (10℃ to 52℃)

(2) For temperature from 40°F(5℃) up to 50°F(10℃), minimum penetrant dwell time shall be 2 times the value listed.

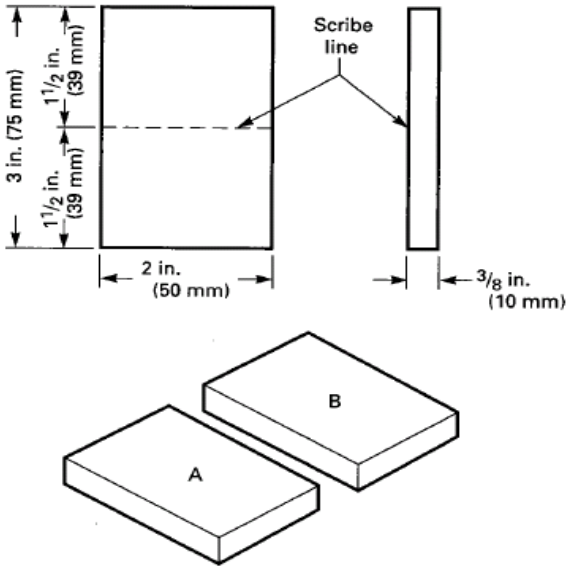


Fig.1 Liquid Penetrant Comparator

Appendix Ⅰ

Procedure Qualification for Essential/Nonessential variable

Essential variable		Ferrous material
1	Identification of and change in type or family group of penetrant materials (inclouding developers, emulsifiers, etc)	DEMONSTRATION (Use Liquid Penetrant Comparation)
2	Surface preparation (finishing and cleaning, including type of cleaning solvent)	AS GROUND AFTER WELDED AS ROLLED AS FORGED(AS MACHINED) In Accordance with para 3.4 in the Procedure.
3	Method of applying penetrant	COMPRESSED-AIR-TYPE(SPRAY TYPE)
4	Method of removing excess surface penetrant	HAND WIPE(WIPING WITH CLOTH)
5	Hydrophilic or lipophilic emulsifiers concentration and dwell time in dip tanks and agitation time for hydrophilic emulsifiers	N/A
6	Hydrophilic emulsifiers concentration in spray applications	N/A
7	Method of applying developer	COMPRESSED-AIR-TYPE(SPRAY TYPE) In accordance with para. 5.5 in this Procedure
8	Minimum and maximum time periods between steps and drying aids	ASME Sec. Ⅴ Art.6 Table T-672
9	Decrease in penetrant dwell time	FOR INCREASE TEMP
10	Increase in developer dwell time (Interpretation time)	INTERPRETATION TIME : (WITHIN 7 TO 60 MIN)
11	Minimum light intensity	MINIMUM 100 fc (1000 lx)
12	Surface temperature outside 50 to 125°F(10 to 52℃) or as previously qualified	IN ACCORDANCE WITH PARA 6.7 IN THIS PROCEDURE
13	Performance demonstration, when required	DEMONSTRATION, WHEN REQUIRED

Procedure Qualification for Essential/Nonessential variable

Nonessential variable		Ferrous material
1	Personnel qualification requirements	ASNT / SNT-TC-1A and/or KOST-QAP-01
2	Material, shapes, or sizes to be examination and the extent of examination	At least 1 in. on each side adjacent to the weld
3	Post examination cleaning technique	AIR SPRAY

Appendix Ⅱ : Report of Liquid Penetrant Examination - A

액 체 침 투 탐 상 검 사 보 고 서
REPORT OF LIQUID PENETRANT EXAMINATION

SUNG JIN GEOTEC CO., LTD
#20-1,SUNG AM-DONG,NAM-KU,ULSAN,KOREA
TEL:(052)228-5801~4,FAX(052)228-5989

Report No. 보고서번호	
Page No. 페이지번호	

Project Name 공사명	Owner / Customer 주문주/고객	Job No. 공사번호
Item Name / 제품명	Item No / 제품번호	Drawing No. 도면번호 Rev No.
Material/Thickness 재질	Surface Temperature 표면온도	Surface Condition 표면조건
		☐ AS-Machined ☐ AS-Grinded ☐ AS-Welded
Process of Penetrant 침투탐상검사공정		Sensitivity 감도
☐ Solvent Removable ☐ Post - Emulsifying		☐Heavy ☐Normal ☐Light Coat

PENETRANT 침 투 제	BRAND	TYPE	BATCH NO.	APPLY	☐ Spray ☐ Brush ☐ Dip	Penetrant Time min
REMOVER 세 척 제	BRLAND	TYPE	BATCH NO.	APPLY	☐ Spray ☐ Brush ☐ Dip	Remove ☐Handwipe ☐Wash
DEVELOPER 현 상 제	BRLAND	TYPE	BATCH NO.	APPLY	☐ Spray ☐ Wet ☐ Brush ☐ Dip ☐ Dry	Developing Time min
BLACKLIGHT 자외선 등	☐ WITH ☐ WITHOUT	BLAND	MODEL NO.	INTENSITY	☐ ft - cd ☐ μ W/㎠	

Acceptance Standard & Applicable procedures / 합격기준 및 적용절차서

★ Inspection Stage 검사시기

A : After Final Weld	R : Root Layer	NSD : Non Significant Defect	O. L : Over Lap
A/P : After P.W.H.T	EP : Edge Preparation	C. C : Crater Crack	G. P : Gas Pore
B/P : Before P.W.H.T	ABG : After Back Gouging	E. C : Edge Crack	L. P : Lack of Penet
A/H : After Hydrotest	TAR : Temporary Attachment Removed	L. C : Longi Crack	L. F : Lack of Fusion
A/F : After Forming	RG : Repair Groove	T. C : Transverse Crack	I. N : Inclusion (Slag)
A/M : After Machining		L. C : Lamination Crack	U. C : Under Cut
B : Bevel angle face			

★★ Interpretation 결함약호

☐ SKETCH ON DOT LINE, IF NECESSARY OR ☐ ATTACHED. 필요시 점선안에 스케치하거나 또는 첨부할 것

Sketch

Identification No. 확 인 번 호	★ Stage	Test Results Grade	Acc	Rej	★★ Interpretation	Welder No. 용접사 번호	Remark 비 고

NDT.Co Operator (Level II)	Witnessed by QC (Level II)	Approved.By LEVEL III	Reviewed by Client	Reviewed by AI

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Appendix II : Report of Liquid Penetrant Examination - B

액 체 침 투 탐 상 검 사 보 고 서
REPORT OF LIQUID PENETRANT EXAMINATION

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Report No. 보고서번호
Page No. 페이지번호

★ Inspection Stage 검사시기 ★★ Interpretation 결함약호

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B : Bevel angle face			

Identification No. 확 인 번 호	★ Stage	Test Results				Welder No. 용접사 번호	Remark 비 고
		Grade	Acc	Rej	★★ Interpretation		