GUIDE FOR

NONDESTRUCTIVE INSPECTION OF HULL WELDS

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American Bureau of Shipping
Incorporated by Act of Legislature of
the State of New York 1862

Updates

February 2012 consolidation includes:

- January 2012 version plus Notice No. 1 and Corrigenda/Editorials

January 2012 consolidation includes:

- September 2011 version plus Corrigenda/Editorials

Foreword

This Guide is the fourth edition of the *Guide for Nondestructive Inspection of Hull Welds*, which was originally published in 1975 and subsequently updated in 1986 and 2002 (the second and third editions). This revision aims to introduce further details of inspection criteria and additional inspection techniques, which are considered as being widely recognized by the industry as a reliable means of inspection of structure members and their welds during the construction of surface vessels and other related marine and offshore structures.

It is intended that this Guide for test procedures and criteria is to be published as a Guide, rather than Rules, in order to collect more feedback from industry during its use and be able to reflect this feedback back into the Guide in a timely manner. Upon completion of this further calibration period, the Guide is to be published as the *Rules for Nondestructive Inspection of Hull Welds*.

This Guide becomes effective on the first day of the month of publication.

Users are advised to check periodically on the ABS website www.eagle.org to verify that this version of this Guide is the most current.

We welcome your feedback. Comments or suggestions can be sent electronically by email to rsd@eagle.org.

GUIDE FOR

NONDESTRUCTIVE INSPECTION OF HULL WELDS

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SECTION 1 General

1 Preparation for Inspection *(1 September 2011)*

1.1 Weld Surface Appearance

Welding in hull construction is to comply with the requirements of Section 2-4-1 "Hull Construction" of the ABS *Rules for Materials and Welding (Part 2)* and IACS Recommendation No. 47 "Shipbuilding and Repair Quality Standard".

Methods used for preparing and cleaning welds and nondestructive test procedures are to be to the satisfaction of the Surveyor.

Slag shall be removed from all completed welds. All welds and adjacent base metal shall be cleaned by wire brushing or by any other suitable means prior to inspection. Surface conditions that prevent proper interpretation may be cause for rejection of the weld area of interest.

1.3 Visual Inspection of Welds

Welds are to be visually inspected to the satisfaction of the Surveyor. Visual inspection acceptance criteria are contained in Section 8 of this Guide.

Visual inspections of welds may begin immediately after the completed welds have cooled to ambient temperature. However, delayed cracking is a concern for extra high-strength steels, 415 N/mm^2 (42 kgf/mm^2, 60,000 psi) yield strength or greater. When welding these high-strength steels, the final visual inspection shall be performed not less than 48 hours after completion of the weld and removal of preheat. Refer to 1/1.5 below for requirements for delayed cracking inspection.

1.5 Inspection for Delayed (Hydrogen Induced) Cracking

1.5.1 Time of Inspection

Nondestructive testing of weldments in steels of 415 N/mm^2 (42 kgf/mm^2, 60,000 psi) yield strength or greater is to be conducted at a suitable interval after welds have been completed and cooled to ambient temperature. The following guidance of interval is to be used, unless specially approved otherwise:

- Minimum 48 hours of interval time for steels of 415 MPa (42 kgf/mm^2, 60,000 psi) yield strength or greater but less than 620 MPa (63 kgf/mm^2, 90,000 psi) yield strength.
- Minimum 72 hours of interval time for steel greater than or equal to 620 MPa (63 kgf/mm^2, 90,000 psi) yield strength.

At the discretion of the Surveyor, a longer interval and/or additional random inspection at a later period may be required. The 72 hour interval may be reduced to 48 hours for radiography testing (RT) or ultrasonic testing (UT) inspection, provided a complete visual and random MT or PT inspection to the satisfaction of the Surveyor is conducted 72 hours after welds have been completed and cooled to ambient temperature.

1.5.2 Delayed Cracking Occurrences

When delayed cracking is encountered in production, previously completed welds are to be re-inspected for delayed cracking to the satisfaction of the Surveyor. At the discretion of the Surveyor, re-qualification of procedures or additional production control procedures may be required for being free of delayed cracking in that production welds.

3 Methods of Inspection *(1 February 2012)*

Inspection of welded joints is to be carried out by approved nondestructive test methods, such as visual inspection (VT), radiography (RT), ultrasonic (UT), magnetic particle (MT), liquid penetrant (PT), etc.. A plan for nondestructive testing is to be submitted. Radiographic or ultrasonic inspection, or both, is to be used when the overall soundness of the weld cross section is to be evaluated. Magnetic-particle or liquid penetrant inspection or other approved method is to be used when investigating the outer surface of welds or may be used as a check of intermediate weld passes such as root passes and also to check back-gouged joints prior to depositing subsequent passes. Surface inspection of important tee or corner joints in critical locations, using an approved magnetic particle or liquid penetrant method, is to be conducted to the satisfaction of the Surveyor. Where a method (such as radiographic or ultrasonic) is selected as the primary nondestructive method of inspection, the acceptance standards of that method govern. However, if additional inspection by any method should indicate the presence of defects that could jeopardize the integrity of structure, removal and repair of such defects are to be to the satisfaction of the Surveyor. Welds that are inaccessible or difficult to inspect in service may be subjected to increase the levels of nondestructive inspection.

The extent and locations of inspection and selection of inspection method(s) are to be in accordance with:

i) The applicable ABS Rules;

ii) The material and welding procedures used;

iii) The quality control procedures involved;

iv) The results of the visual inspection, and

v) The discretion of the Surveyor;

Where the length and number of inspection points is over and above the minimum requirements indicated on the inspection plan and as specified herein, then the length of any supplementary NDE may be reduced subject to the agreement with the attending Surveyor.

The extent of inspection of repaired locations is to be to the satisfaction of the attending Surveyor.

5 Personnel *(1 September 2011)*

The Surveyor is to be satisfied that personnel responsible for conducting nondestructive tests are thoroughly familiar with the equipment being used and that the technique and equipment used are suitable for the intended application. For each inspection method, personnel are to be qualified by training, with appropriate experience and certified to perform the necessary calibrations and tests and to interpret and evaluate indications in accordance with the terms of the specification. Personnel certified in accordance with the International Standard ISO 9712 – *Non-destructive testing – Qualification and certification of personnel*, shall be classified in any one of the following three levels. Personnel who have not attained certification may be classified as trainees.

The requirements of other internationally/nationally recognized certifying programs (e.g., ASNT Central Certification Program (ACCP), EN-473, etc., see Subsection 1/13 below) are to be specially considered.

For future incorporation of phased-array ultrasonic (PAUT) and time of flight diffraction (TOFD) techniques, at the time of publication, only the EN-473 program has specific qualification and certification for these two advanced methods of NDT.

5.1 NDT Trainee

A trainee is an individual who works under the supervision of certified personnel but who does not conduct any tests independently, does not interpret test results and does not write reports on test results. This individual may be registered as being in the process of gaining appropriate experience to establish eligibility for qualification to Level I or for direct access to Level II.

5.3 NDT Level I

An individual certified to NDT Level I may be authorized to:

i) Set up the equipment;

ii) Carry out NDT operations in accordance with written instructions under the direct supervision of level II and/or level III personnel;

iii) Perform the tests;

iv) Record the conditions and date of the tests;

v) Classify, with prior written approval of a level III, the results in accordance with documented criteria, and report the results.

An individual certified to Level I is not to be responsible for the choice of the test method or technique to be used.

5.5 NDT Level II

An individual certified to NDT Level II may be authorized to perform and direct nondestructive testing in accordance with established or recognized procedures. This may include:

i) Defining the limitations of application of the test method for which the Level II individual is qualified;

ii) Translating NDT codes, standards, specifications and procedures into practical testing instructions adapted to the actual working conditions;

iii) Setting up and verifying equipment settings;

iv) Performing and supervising tests;

v) Interpreting and evaluating results according to applicable codes, standards and specifications;

vi) Preparing NDT instructions;

vii) Conducting or direct supervision of all Level I duties;

viii) Training or guiding personnel below Level II, and

ix) Organizing and reporting results of nondestructive tests.

5.7 NDT Level III

5.7.1

An individual certified to NDT Level III may be authorized to direct any operation in the NDT method(s) for which he is certified. This may include:

i) Assuming full responsibility for an NDT facility and staff;

ii) Establishing and validating techniques and procedures;

iii) Interpreting codes, standards, specifications and procedures;

iv) Designating the particular test methods, techniques and procedures to be used for specific NDT work;

v) Interpreting and evaluating results in terms of existing codes, standards and specifications;

vi) Managing qualification examinations, if authorized for this task by the certification body, and

vii) Conducting or supervising all Level I and Level II duties.

5.7.2

An individual certified to Level III shall have:

i) Sufficient practical background in applicable materials, fabrication and product technology to select methods and establish techniques and to assist in establishing acceptance criteria where none are otherwise available;

ii) A general familiarity with other NDT methods; and

iii) The ability to train or guide personnel below level III.

7 NDT Procedures and Techniques *(1 September 2011)*

Procedures and techniques shall be established and approved by personnel certified to NDT level III in the applicable inspection method.

Techniques shall be prepared in accordance with the requirements stated in the applicable NDT section of this Guide.

NDT inspection shall be performed by certified level I, II or III personnel.

Interpretation and evaluation of inspection results shall be performed by personnel certified to NDT level II and/or III in the applicable NDT inspection method.

9 Acceptance Criteria *(1 September 2011)*

Acceptance Criteria specified herein are only applicable to inspections required by the Rules and by the Surveyor.

11 Documentation

Adequate information as to the NDT methods, extent, location(s) and results of inspection shall be included in inspection records or reports so that conformity with the applicable NDT requirements is properly documented.

13 References of Qualification/Certification Programs *(1 September 2011)*

1. ISO 9712, Nondestructive Testing - Qualification and Certification of Personnel
2. ASNT Central Certification Program (ACCP)
3. ASNT ACCP Level II certification for meeting the requirements of ISO 9712 Level II certification
5. NAS 410, Minimum requirements for the qualification and certification of NDT personnel
6. CGSB, Canadian General Standards Board (CGSB) - Certification and Qualification Programs
7. EN 473, Non-Destructive Testing. Qualification and Certification of NDT Personnel

15 Nondestructive Testing Terminology *(1 September 2011)*

The standard terminology for nondestructive testing as described in ASTM E1316 shall be used, except as noted otherwise.

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SECTION 2 Radiographic Inspection

1 General *(1 September 2011)*

Radiographs shall be made using a single source of either x- or gamma radiation. These requirements are intended to apply to full penetration welds of steel and aluminum alloys.

3 Surface Condition

3.1 General *(1 September 2011)*

The inside and outside surfaces of the welds to be radiographed are to be sufficiently free from irregularities that may mask or interfere with interpretation. Welds and inspection surfaces are subject to the requirements of Subsection 1/1 of this Guide.

3.3 Cause for Rejection

Surface conditions that prevent proper interpretation of radiographs may be cause for rejection of the weld area of interest.

5 Radiographic Procedure

5.1 Personnel *(1 September 2011)*

The Surveyor is to be satisfied that NDT personnel are qualified and certified in accordance with Subsection 1/5.

5.3 Technique *(1 September 2011)*

5.3.1

Steel welds and structures can be radiographed by utilizing either gamma rays or x-rays. Aluminum alloys can be only radiographed by x-rays. Section 2, Table 1 below summarizes the methods to be used.

5.3.2

Wherever geometry permits, radiography is to be performed by the single-wall technique. In this technique, radiation passes through only one wall of the weld or structure. The radiation source is to be centered with respect to the length and width of the weld being radiographed.

TABLE 1
Material and Inspection Method *(1 September 2011)*

Materials	*Thickness t, mm (in.)*	*Inspection Method*
Steels	$t < 9$ mm ($^{11}/_{32}$ in.)	x-rays or Iridium 192 (^{192}Ir)
	9 mm ($^{11}/_{32}$ in.) $\le t \le$ 75 mm (3 in.)	x-rays or Iridium 192 (^{192}Ir)
	$t > 75$ mm (3 in.)	Cobalt 60 (^{60}Co)
Aluminum Alloys	$t \le 75$ mm (3 in.)	x-rays with Beryllium window
	$t > 75$ mm (3 in.)	RT is not recommended

Note: The principle for selecting x-rays or gamma rays is determined based on density and thickness of the test material. Thin/less dense material requires less radiation energy. Cobalt 60 emits two gamma rays at 1170 and 1330 keV and Iridium 192 emits several gamma rays with energies from 140 to 1200 (average about 340) keV. Typically, an industrial x-ray tube's target material is tungsten which has K shell emission at about 60 keV.

5.5 Film Identification

5.5.1 General

The radiographic film is to be properly marked to clearly indicate the hull number, or other equivalent traceable identification, and to identify the exact location of the area radiographed.

5.5.2 Multiple Films *(1 September 2011)*

When more than one film is used to inspect a length of weld or a complete circumferential weld, identification markers are to appear on each film, such that each weld section reference marker location is common to two successive films to establish that the entire weld has been inspected.

A radiograph of a repaired weld is to be identified with an "R". Refer to Subsection 2/19.

5.7 Radiography Quality Level

5.7.1 General

The radiographic quality level is a combination of radiographic contrast and definition.

5.7.2 Radiographic Contrast

(1 September 2011) Radiographic contrast is the difference in density between two adjacent areas on the film. It is primarily controlled by the energy level of the radiation source and type of film used. The fastest speed of film that provides the required quality level and definition may be used. The density contrast curve for the film, which is provided by film manufacturer, shall have a minimum of 5:1 ratio with the lightest density not less than 2.0.

5.7.2(a) Radiographic contrast can be greatly affected and reduced by back-scattered radiation. Back-scattered radiation is radiation that has passed through the weld and film, but is reflected back to the film by surfaces behind the film. Dependent on the film location, the surfaces may be bulkheads, pipes, tanks, etc. To verify that backscatter radiation is not a problem, a lead letter "B" is to be attached to the center of the rear of the film cassette. The size of the lead letter "B" is to be 12.5 mm ($^1/_2$ in.) high and 1.6 mm ($^1/_{16}$ in.) thick.

5.7.2(b) During interpretation of the radiograph, a light image of the lead letter "B" indicates a backscatter problem. The applicable radiograph(s) is to be considered unacceptable and the weld area of interest is to be re-radiographed.

5.7.2(c) To reduce the undesirable effects of back-scattered radiation, a thin sheet of lead can be placed behind the film cassette.

5.7.3 Radiographic Definition

Radiographic definition refers to the sharpness of the image outline and is controlled by geometric unsharpness.

5.7.4 Geometric Unsharpness

Due to sources of penetrating radiation having physical dimensions, radiographic images have an inherent shadow. This is referred to as geometric unsharpness (U_g). To improve the ability to detect images of fine discontinuities, it is required that the physical dimension of U_g be kept to a maximum, see Section 2, Table 2 below.

TABLE 2
Geometric Unsharpness U_g

Material Thickness in Area of Interest, mm (in.)	*Maximum U_g, mm (in.)*
0 - 50 (0 - 2)	0.50 (0.020)
50 - 75 (2 - 3)	0.75 (0.030)
75 - 100 (3 - 4)	1.00 (0.040)
> 100 (> 4)	1.75 (0.070)

5.7.5 Source-to-Film Distance *(1 September 2011)*

The correct source-to-film distance (*SFD*) is an important consideration in ensuring that the required radiographic quality level is obtained and controls the geometric unsharpness.

Calculation of the correct U_g and *SFD* may be by a mathematical formula or prepared diagrams (nonograms).

$$U_g = \frac{f \times d}{D}$$

where (as shown in Section 2, Figure 1)

U_g = geometric unsharpness

f = physical size of the radiation source

d = distance from the front of the inspection component to the radiographic film

D = distance from the front of the inspection component to the radiation source

Therefore, $d + D = SFD$, and this calculation is to be included in the radiographic procedure/technique.

The *SFD* is not to be less than the total length of the radiographic film being exposed.

5.7.6 Minimum Quality Level

All radiographs are to have a minimum quality level of 2-4T or equivalent.

The quality level may be considered as acceptable when the image of the applicable Image Quality Indicator (IQI) is clearly shown within the area of interest.

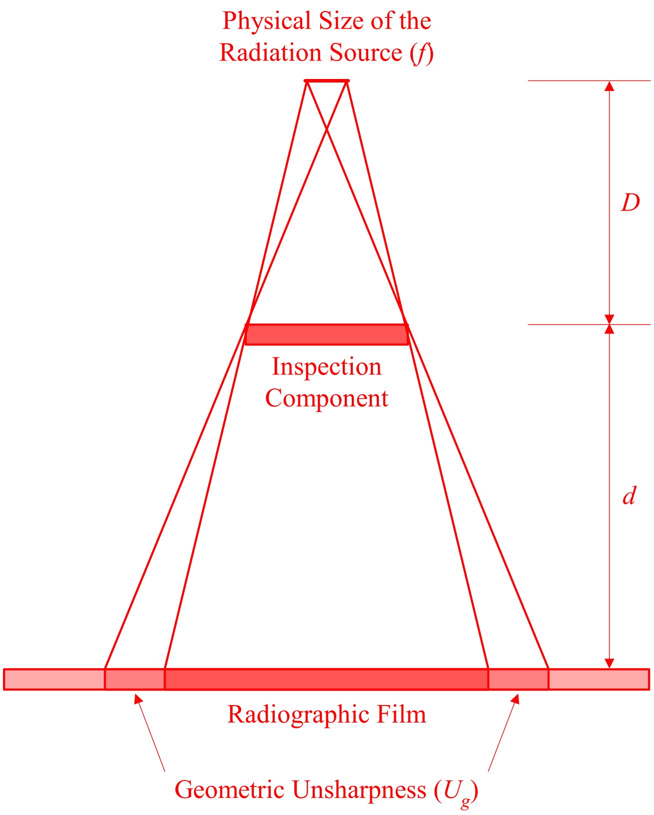
5.7.7 Film Length and Width *(1 September 2011)*

Film shall have sufficient length and shall be placed to provide at least 12 mm (½ in.) of film beyond the projected edge of the weld.

Welds longer than 350 mm (14 in.) may be radiographed by overlapping film cassettes and making a single exposure, or by using single film cassette and making separate exposures. In such case, the provision in 2/5.7.4 geometric unsharpness (U_g) requirement shall apply.

Film widths shall be sufficient to depict all portions of the weld joints, including heat-affected zones (HAZs), and shall provide sufficient additional space for the required hole-type IQIs or wire IQI and film identification without infringing upon the area of interest in the radiograph.

FIGURE 1
Geometric Unsharpness *(1 September 2011)*



5.9 Image Quality Indicator (IQI)

5.9.1 General *(1 September 2011)*

Radiographic sensitivity shall be judged based on either standard hole-type (plaque) or wire IQIs. The radiographic technique and equipment shall provide sufficient sensitivity to clearly delineate the required IQIs with essential holes or wires as described in the following paragraphs and in Section 2, Tables 3 to 6 below.

Hole-type IQI is to conform to ASTM Standard E 1025 and wire-type IQI is to conform to ASTM Standard E 747 or ISO Standard 1027.

TABLE 3
Hole-type IQI Selection

Nominal Material Thickness Range, mm (in.)	*SOURCE SIDE*		*FILM SIDE*	
	Designation	*Essential Hole*	*Designation*	*Essential Hole*
Up to 6.5 (0.25) incl.	10	4T	7	4T
Over 6.5 (0.25) through 9.5 (0.375)	12	4T	10	4T
Over 9.5 (0.375) through 12.5 (0.50)	15	4T	12	4T
Over 12.5 (0.50) through 16.0 (0.625)	15	4T	12	4T
Over 16.0 (0.625) through 19.0 (0.75)	17	4T	15	4T
Over 19.0 (0.75) through 22.0 (0.875)	20	4T	17	4T
Over 22.0 (0.875) through 25.0 (1.00)	20	4T	17	4T
Over 25.0 (1.00) through 31.5 (1.25)	25	4T	20	4T
Over 31.5 (1.25) through 38.0 (1.50)	30	2T	25	2T
Over 38.0 (1.50) through 50.0 (2.00)	35	2T	30	2T
Over 50.0 (2.00) through 62.5 (2.50)	40	2T	35	2T
Over 62.5 (2.50) through 75.0 (3.00)	45	2T	40	2T
Over 75.0 (3.00) through 100.0 (4.00)	50	2T	45	2T
Over 100.0 (4.00) through 150.0 (6.00)	60	2T	50	2T
Over 150.0 (6.00) through 200.0 (8.00)	80	2T	60	2T

TABLE 4
Wire IQI Selection

Nominal Material Thickness Range, mm (in.)	*SOURCE SIDE Maximum Wire Diameter*	*FILM SIDE Maximum Wire Diameter*
	mm (in.)	*mm (in.)*
Up to 6.5 (0.25) incl.	0.25 (0.010)	0.20 (0.008)
Over 6.5 (0.25) through 10.0 (0.375)	0.33 (0.013)	0.25 (0.010)
Over 10.0 (0.375) through 16.0 (0.625)	0.41(0.016)	0.33 (0.013)
Over 16.0 (0.625) through 19.0 (0.75)	0.51 (0.020)	0.41(0.016)
Over 19.0 (0.75) through 38.0 (1.50)	0.63 (0.025)	0.51 (0.020)
Over 38.0 (1.50) through 50.0 (2.00)	0.81 (0.032)	0.63 (0.025)
Over 50.0 (2.00) through 62.5 (2.50)	1.02 (0.040)	0.81 (0.032)
Over 62.5 (2.50) through 100.0 (4.00)	1.27 (0.050)	1.02 (0.040)
Over 100.0 (4.00) through 150.0 (6.00)	1.60 (0.063)	1.27 (0.050)
Over 150.0 (6.00) through 200.0 (8.00)	2.54 (0.100)	1.60 (0.063)

TABLE 5
ASTM Wire IQI Designation, Wire Diameter and Wire Identity *(1 September 2011)*

Set A		*Set B*		*Set C*		*Set D*	
Wire Diameter, mm (in.)	*Wire Identity*	*Wire Diameter, mm (in.)*	*Wire Identity*	*Wire Diameter, mm (in.)*	*Wire Identity*	*Wire Diameter, mm (in.)*	*Wire Identity*
0.08 (0.0032)	1	0.25 (0.010)	6	0.81 (0.032)	11	2.54 (0.100)	16
0.10 (0.0040)	2	0.33 (0.013)	7	1.02 (0.040)	12	3.20 (0.126)	17
0.13 (0.0050)	3	0.41 (0.016)	8	1.27 (0.050)	13	4.06 (0.160)	18
0.16 (0.0063)	4	0.51 (0.020)	9	1.60 (0.063)	14	5.08 (0.200)	19
0.20 (0.0080)	5	0.63 (0.025)	10	2.03 (0.080)	15	6.35 (0.250)	20
0.25 (0.0100)	6	0.81 (0.032)	11	2.54 (0.100)	16	8.13 (0.320)	21

TABLE 6
ISO Wire IQI Designation, Wire Diameter and Wire Identity *(1 September 2011)*

W1 FE (W1-W7)		*W6 FE (W6-W12)*		*W10 FE (W10-W16)*		*W13 FE (W13-W19)*	
Wire Diameter, mm (in.)	*Wire Identity*	*Wire Diameter, mm (in.)*	*Wire Identity*	*Wire Diameter, mm (in.)*	*Wire Identity*	*Wire Diameter, mm (in.)*	*Wire Identity*
3.20 (0.125)	1	1.02 (0.040)	6	0.41 (0.016)	10	0.20 (0.0080)	13
2.54 (0.100)	2	0.81 (0.032)	7	0.33 (0.013)	11	0.16 (0.0063)	14
2.03 (0.080)	3	0.63 (0.025)	8	0.25 (0.010)	12	0.127 (0.0050)	15
1.60 (0.063)	4	0.51 (0.020)	9	0.20 (0.0080)	13	0.10 (0.0040)	16
1.27 (0.050)	5	0.41 (0.016)	10	0.16 (0.0063)	14	0.08 (0.0032)	17
1.02 (0.040)	6	0.33 (0.013)	11	0.127 (0.0050)	15	0.063 (0.0025)	18
0.81 (0.032)	7	0.25 (0.010)	12	0.10 (0.0040)	16	0.051 (0.0020)	19

5.9.2 Hole-type (Plaque – Penetrameter) IQI

With this type of IQI, the required quality level is achieved when, in addition to the image of the applicable hole, a minimum of three sides of the plaque image can be distinguished. A shim of material that is radiographically similar to the weld material may be used to provide the same amount of thickness below the IQI as the maximum thickness of the weld reinforcement. The size of the shim is to be a minimum of 3 mm ($^1/_8$ in.) larger than the plaque IQI.

The IQI is to be placed parallel to the longitudinal axis of the weld. The position of the IQI is to be such that the image of the IQI and shim is not to be projected within the area of interest. The area of interest is the weld, heat-affected zone (HAZ), and backing material, if used.

5.9.3 Wire IQI

There are presently two types of wire IQIs in use. Both consist of parallel strips of wires of varying diameters encased vertically in a clear, sealed plastic pouch. The Surveyor is to verify that the required image of the correct diameter wire is shown within the area of interest.

5.9.3(a) *(1 September 2011)* The ASTM IQI consists of six (6) wires, see Section 2, Table 5, with the thickness of each wire increasing from left to right.

5.9.3(b) *(1 September 2011)* The ISO IQI consists of seven (7) wires, see Section 2, Table 6, with the thickness of each decreasing from left to right.

5.9.3(c) The ASTM or ISO IQI is to be placed perpendicular to the longitudinal axis of the weld, such that the projected image is within the weld image. The required sensitivity is achieved when the required diameter wire image is visible within the weld image.

5.9.3(d) As the wire is placed in a transverse position across the face reinforcement, shims are not required.

5.9.4 IQI Selection

Selection of the applicable IQI quality level is to be based upon the plate thickness plus allowable weld reinforcement. Weld reinforcement is to be a combination of face plus root reinforcement. Backing material is not considered as part of the weld when selection of the IQI is made (refer to Section 2, Tables 3 and 4).

5.9.5 Location of IQI

Regardless of the IQI design, the IQI is to be placed on the side of the weld facing the source of radiation (source side) in the worst geometrical position which is required at either end of the applicable length of weld under inspection.

5.9.5(a) Film Side Placement of IQIs . If an IQI cannot be physically placed on the side of the weld facing the source of radiation, the IQI may be placed in contact with the back surface of the weld. This is to be indicated by the placement of a lead letter “F” adjacent to the IQI.

5.9.5(b) Level of Sensitivity. To maintain the required level of sensitivity, the plaque thickness or the wire diameter is to be one size less than stated for source side placement (refer to Section 2, Tables 3 and 4).

5.11 Radiographic Density

5.11.1 General

Radiographic density is a measure of the film blackness. It is a logarithmic scale of light transmission through the film image and is accurately measured with a calibrated electronic transmission densitometer.

5.11.2 Calibration of Densitometer

Calibration of the densitometer instrument is to be verified by comparison to a calibrated step-wedge film.

5.11.2(a) The calibrated step-wedge film is to be traceable to the National Institute of Standards and Technology (NIST) or other equivalent national standard.

5.11.2(b) Calibration of the instrument is to be verified and documented every 30 days.

5.11.3 Step-Wedge Film Density

Verification of radiographic film density by direct comparison with a step-wedge film is more subjective than when using an electronic densitometer. Improper storage can lead to degradation of the accuracy of step-wedge films. Therefore, close attention is to be paid to the physical condition of the step-wedge film.

5.11.3(a) When radiographic density is verified solely with the use of a calibrated step-wedge film, the calibration date of the film is to be within the previous 12 months of use.

5.11.3(b) The calibrated step-wedge film is to be traceable to the National Institute of Standards and Technology (NIST) or other equivalent national standard.

5.11.4 Radiographic Film Density Requirements

The minimum density for single film viewing is to be 1.8 H&D for x-ray film and 2.0 H&D for gamma ray film.

5.11.4(a) The maximum density for single film viewing is to be 4.0 H&D for both x-ray and gamma ray films.

5.11.4(b) The base density of unexposed radiographic film is not to exceed 0.30 H&D.

5.11.4(c) When wire IQIs are used, a minimum of two density readings are required, one at each end of the area of interest.

5.11.4(d) When plaque IQIs are used, an additional density reading is to be taken through the body of the IQI on the shim. A density variation of +15% with the density of the area of interest is acceptable.

A density reading lower than the area of interest is acceptable as long as the minimum required density and quality level are obtained.

5.13 Radiographic Film Quality

5.13.1 General

Radiographs are to be processed in accordance with film manufacturer's recommendations, especially with regard to temperature and time control.

5.13.2 Artifacts and Blemishes

All radiographs are to be free of mechanical and/or processing artifacts and blemishes within the area of interest.

Radiographs with artifacts or blemishes that interfere with interpretation of the area of interest are unacceptable. The weld area of interest is to be re-radiographed.

5.15 Radiographic Film Interpretation

5.15.1 General *(1 September 2011)*

Film interpretation and evaluation are only to be undertaken by qualified and certified Level II and/or Level III industrial radiographers.

5.15.2 Film Viewing Facilities

Viewing and interpretation of finished radiographs are to be in an area that is clean, quiet, and provides subdued background lighting.

5.15.2(a) The viewing screen is to be clean and free of blemishes and marks.

5.15.2(b) The viewing light is to provide sufficient and variable intensity to view radiographs with a maximum density of 4:0 H&D.

7 Storage of Radiographs

7.1 General *(1 September 2011)*

The contract between the ship Owner and shipyard generally stipulates the period of time and storage location for completed radiographs.

Archive quality of the film shall be according to ISO 18917: *Photography – Determination of residual thiosulfate and other related chemicals in processed photographic materials – Methods using iodine-amylose, methylene blue and silver sulfide*, or in accordance with the film manufacturer recommended techniques. ASTM E 1254 is referred for Guide to Storage of Radiographs and Unexposed Industrial Radiographic Films.

7.3 Temperature and Humidity Control *(1 September 2011)*

Temperature and humidity control is required so that no deterioration of the radiographic image occurs.

7.5 Documentation and Filing System

An orderly documentation and filing system is to be implemented, such that the Surveyor can review radiographs within a reasonable period of time of request.

9 Report *(1 September 2011)*

Radiographic examination reports are to be filed for record and are to include the following items as a minimum:

i) Hull number, exact location and length of the welds inspected

ii) Base material type and thickness, weld thickness range and joint type

iii) Radiation source used

iv) X-ray voltage or isotope type used

v) Distance from radiation source to weld

vi) Distance from source side of weld to radiographic film

vii) Angle of radiation beam through the weld (from normal)

viii) Width of radiation beam

ix) Film manufacturer's type/designation and number of film in each film holder/cassette

x) Number of radiographs (exposures)

xi) IQI type and location (source side or film side)

xii) Specific acceptance class criteria for radiographic examination

xiii) Dates of inspection and signature of radiographic examination operator

xiv) Evaluation of weld(s) examined, evaluation date, name and signature of evaluator

11 Digital Imaging Systems *(1 September 2011)*

11.1 General

In case of use of digital radiography (DR) to view and capture/store the image in electronic forms for viewing and evaluation for acceptance and rejection, the sensitivity of such examination as seen on the monitoring equipment and the recording medium shall not be less than that required for conventional film radiographic test. It is recommended to follow ASME Section V to meet the general requirements on DR method with regard to equipment, calibration, examination & inspection, evaluations, recording and documentation.

11.3 Procedure and Report

In addition to applicable items listed in Subsection 2/9 above, the procedure and report shall also contain the following essential items for a digital imaging system:

i) Data of the monitoring equipment, including manufacturer, make, model, and serial number

ii) Image acquisition equipment manufacturer, model, and serial number

iii) Radiation and imaging control setting for each combination of variables established herein

iv) Scanning speed,

v) Image conversion screen to weld distance,

vi) IQI type and location (source side or screen side),

vii) Computer enhancement (if used),

viii) Imaging software version and revision

ix) Numerical values of the final image processing parameters (i.e., window (contrast), and level (brightness) for each view)

x) Type of imaging recording medium,

xi) Identification of the image file and its location

The technique details may be embedded in the detail file. When this is done, ASTM E 1475, Standard Guide for Data Fields for Computerized Transfer of Digital Radiographical Examination Data, may be used as guidance.

11.5 Record

Examinations used for acceptance or rejection of welds shall be recorded on an acceptable medium. The record shall be in-motion or static. A written record shall be included with the recorded images giving the following information as a minimum:

i) Identification and description of welds examined

ii) Procedure(s) and equipment used

iii) Location of the welds within the recorder medium

iv) Results, including a list of unacceptable welds, repairs and their locations within the recorded medium.

The control of documentations on unprocessed original images (raw images) and the digitally processed images in DR method are to be to the satisfaction of the Surveyor. Permanent records of all interpretable indications are to be stored electronically (such as on CD-ROM), maintained and retrievable throughout the life of the vessels or structures.

13 Extent of Radiographic Inspection

13.1 General *(1 September 2011)*

Provision is to be made for the Surveyor to verify the radiographic inspection and examine radiographs of a representative number of checkpoints. The weld length of inspection is to be indicated in the inspection plan required by the applicable Rule requirements and by the Surveyor.

If RT is the primary method of volumetric inspection and the minimum extent of RT coverage meets the extent requirements to the surveyors satisfaction, then any supplementary UT proposed is permitted to be to a minimum check length of 500 mm (20 in.) as indicated in 3/5.1.

13.3 Surface Vessels

The minimum extent of radiographic inspection within the midship 0.6L of surface vessels is to be governed by the following equation:

$n = L(B + D)/46.5$ SI and MKS units or $n = L(B + D)/500$ US units

where

n = minimum number of checkpoints

L = length of the vessel between perpendiculars, in m (ft)

B = greatest molded breadth, in m (ft)

D = molded depth at the side, in m (ft), measured at $L/2$.

Consideration may be given for reduction of inspection frequency for automated welds where quality assurance techniques indicate consistent satisfactory quality.

The number of checkpoints is to be increased if the proportion of non-conforming indications is abnormally high.

13.5 Other Marine and Offshore Structures *(1 September 2011)*

The extent of radiographic inspection for other marine and offshore structures is to be governed by the applicable Rule requirements (e.g., ABS *Rules for Building and Classing Mobile Offshore Drilling Units*).

15 Location of Radiographic Inspection

15.1 General

In selecting checkpoints, the following should be given emphasis in the selection of inspection locations:

i) Welds in high stressed areas

ii) Other important structural elements

iii) Welds which are inaccessible or very difficult to inspect in service

iv) Field erected welds

v) Suspected problem areas

15.3 Surface Vessels

Radiographic inspection within the midship 0.6*L* is to be carried out mainly in locations such as:

i) Intersections of butts and seams in the sheer strakes, bilge strakes, deck stringer plates and keel plates

ii) Intersections of butts in and about hatch corners in main decks

iii) In the vicinity of breaks in the superstructure

At the discretion of the Surveyor, radiographic inspection outside the midship 0.6*L* is to be carried out at random in important locations, such as those specified above.

15.5 Other Marine and Offshore Structures *(1 September 2011)*

Radiographic inspection is to be carried out at locations specified in the approved plans and by the Rules applicable to the structure (e.g., ABS *Rules for Building and Classing Mobile Offshore Drilling Units*).

17 Acceptance Criteria for Radiographic Inspection *(1 September 2011)*

17.1 Applicability

The acceptance criteria of Section 8 is applicable for full penetration butt welds in locations where radiographic inspection is carried out in accordance with this Guide and where required by the Surveyor.

The acceptance criteria of Section 8 is not intended to apply to supplementary inspections conducted beyond Rule requirements.

19 Treatment of Welds with Non-conforming Indications

19.1 General *(1 September 2011)*

All radiographs of welds exhibiting non-conforming indications are to be brought to the attention of the Surveyor. Such welds are to be repaired and inspected as required by the Surveyor.

19.3 Extent of Indication at One Location

Unless otherwise required by the Surveyor, when non-conforming indications are concentrated at one location away from the ends of the radiograph, only this location need be repaired or otherwise treated to the satisfaction of the Surveyor. No additional radiographic inspection is required in the adjacent area.

19.5 Extent of Indication at the End of a Radiograph

When non-conforming indications are observed at the end of a radiograph, additional radiographic inspection is generally required to determine their extent.

As an alternative, the extent of non-conforming welds may be ascertained by excavation, when approved by the Surveyor.

19.7 Additional Inspection

When a series of non-conforming indications is observed on a radiograph, and the pattern of the indications suggests that non-conforming discontinuities may exist for an extended distance, additional inspection is to be carried out to the satisfaction of the Surveyor.

21 References *(1 September 2011)*

i) American Welding Society (AWS), D1.1, *Structural Welding Code, Steel*.

ii) ASME Section V, Article 2 and Article 22

iii) ASTM E94, *Standard Guide for Radiographic Examination*.

iv) ASTM E747, *Standard Practice for Design, Manufacturer and Material Grouping Classification of Wire Image Quality Indicators (IQI) Used for Radiology*.

v) ASTM E1025, *Standard Practice for Design, Manufacturer and Material Grouping Classification of Hole-Type Image Quality Indicators (IQI) Used for Radiology*.

vi) ASTM E1032, *Standard Test Method for Radiographic Examination of Weldments*.

vii) ASTM E 1475, *Standard Guide for Data Fields for Computerized Transfer of Digital Radiographical Examination Data*

viii) ASTM E 1254, *Standard Guide for Storage of Radiographs and Unexposed Industrial Radiographic Films*

ix) ISO 1027, *Radiographic Image Quality Indicators for Non-destructive Testing – Principles and Identification*.

x) ISO 18917, *Photography – Determination of residual thiosulfate and other related chemicals in processed photographic materials – Methods using iodine-amylose, methylene blue and silver sulfide*.

SECTION 3 Ultrasonic Inspection

1 General *(1 September 2011)*

When ultrasonic inspection is to be used as an inspection method at a shipyard, it is to the Surveyor's satisfaction of the yard's capability with this inspection method. Several important considerations, which should be investigated, are the yard's operator training and qualifying practices, reliability and reproducibility of results and the proper application of approved procedures and acceptance standards.

Where a yard desires to use ultrasonic inspection as the primary inspection method, such testing is to be initially and periodically supplemented or complemented with random radiographic inspections to confirm ultrasonic flaw indications. This Guide currently covers conventional ultrasonic testing with straight beam and angle beam techniques. However, advanced techniques such as automated ultrasonic testing (AUT) with encoded computer program control or phased array ultrasonic testing (PAUT) with A, B, or C scan or time of flight diffraction (TOFD) technique may be used to provide permanent records, provided appropriate training of the operator in advanced techniques is to satisfaction of the Surveyor.

Records are to be kept concerning the nature and severity of the indications and the amount of repair weld required based on each inspection method.

In addition to the ultrasonic inspection, the Surveyors may, at their discretion, require supplementary nondestructive testing, such as radiography, to verify the adequacy of the quality control system.

The acceptance requirements contained herein are intended for the ultrasonic inspection of full penetration welds in hull structures of surface vessels, and when indicated by ABS, may also be applied to other marine and offshore structures. They are not intended to cover material with thickness less than 8 mm ($^5/_{16}$ in.) for which modified techniques and standards would be required (see Appendix 2 for guidance). These requirements are primarily intended for the inspection of carbon and low alloy steels. The requirements may be applied for the inspection of material with different acoustical properties, such as aluminum or stainless steel, provided the transducer design and calibration block material used are appropriate to the acoustical properties of the material under inspection.

Variations from the techniques recommended herein may be given consideration if they are shown to be more suitable to special situations. Ultrasonic inspection of materials with thickness less than 8 mm ($^5/_{16}$ in.) may be specially considered when proposed as a substitute for radiography.

3 Ultrasonic Procedure *(1 September 2011)*

3.1 Personnel

The Surveyor is to be satisfied that NDT personnel are qualified and certified in accordance with Subsection 1/5.

When inspection is conducted by PAUT or TOFD technique, the operator must provide proof of suitable training to apply this technique.

3.3 Technique

An acceptable pulse echo ultrasonic technique is to be followed, such as that indicated in ASTM E164 or other recognized standards.

3.5 Calibration Blocks

3.5.1 IIW Block

Distance calibration (horizontal sweep) is to be performed using The International Institute of Welding (IIW) ultrasonic reference block Type US-1 as shown in Section 3, Figure 1A. Other more portable blocks of approved design may be permitted for field use such as Type MAB Miniature Angle-Beam reference block (Section 3, Figure 1B) and Type DSC Distance and Sensitivity reference (Section 3, Figure 1C), provided they meet the intended requirements.

For resolution calibration (RC) of angle beam transducer, the IIW reference block shown in Section 3, Figure 1D, may be used.

3.5.2 Basic Calibration Block(s)

Sensitivity calibration is to be performed using the Basic Calibration Block appropriate for the weld thickness to be inspected as shown in Section 3, Figure 2. Where the block thickness ±25 mm (±1 in.) spans two of the weld thickness ranges shown in Section 3, Figure 2, the block's use is acceptable in those portions of each thickness range covered by 25 mm (1 in.).

3.5.2(a) Block Selection. The material from which the block is fabricated is to be of the same product form, heat treatment, material specification and acoustically similar as the materials being examined. For calibration blocks for dissimilar metal welds, the material selection is to be based on the material on the side of the weld from which the examination is to be conducted. If the examination is conducted from both sides, calibration reflectors are to be provided in both materials. Where two or more base material thicknesses are involved, the calibration block thickness is to be determined by the average thickness of the weld.

3.5.2(b) Surface Finish. The finish on the surfaces of the block (from which the scanning is to be conducted) is to be representative of the surface finishes on the components to be examined.

3.5.2(c) Block Quality. The material from which the calibration block is to be made is to be completely examined with a straight beam search unit and is to be free of internal discontinuities.

Note: In the case of PAUT or TOFD technique, the reference calibration blocks are to be made to meet the ASME Section V requirements.

3.7 Ultrasonic Equipment

3.7.1 General

A pulse-echo ultrasonic instrument shall be used. The instrument shall be capable of displaying an A-scan rectified trace and operation at frequencies over a range of at least 1 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.

3.7.2 Basic Instrument Qualification

Basic instrument qualification is to be made once each three (3) months or whenever maintenance is performed which affects the function of the equipment (whichever is less). Basic instrument qualification is to include checks of vertical linearity and horizontal linearity. A 12.5 mm ($^1/_2$ in.) diameter 2.25 MHz (or nearest size and frequency) compressional (straight beam) transducer is to be used as a master transducer for instrument qualifications. The master transducer is to be used primarily for qualification purposes and is not to be used for general inspections.

The standard International Institute of Welding (IIW) Reference Block Type US-1, shown in Section 3, Figure 1A is to be used for instrument qualification. Other types of reference blocks may also be used provided they provide the same sensitivity and functions, as does the IIW Reference Block.

3.7.2(a) Horizontal Linearity. The horizontal (range) linearity of the test instrument shall be qualified over the full sound-path distance being used during testing. For this qualification, the master transducer creating longitudinal (compression) waves is used. The procedures for horizontal linearity qualification are outlined as follows:

- Couple the straight-beam master transducer on the end surface (position 1 in Section 3, Figure 1A) of the IIW reference block to calibrate for a full range of 200 mm (8 in.)
- Place the master transducer over 100 mm (4 in.) width side (position 2 in Section 3, Figure 1A). Two (2) peaks at equal distance are expected.
- Place the master transducer over the thickness of the block (position 3 in Section 3, Figure 1A) and eight (8) peaks at equal distance are expected
- When properly adjusted each intermediate trace deflection location shall be correct within ±5% of the screen width.

3.7.2(b) Vertical (Amplitude Control) Linearity. To determine the accuracy of the amplitude control of the instrument, position the master transducer over the 1.5 mm ($^1/_{16}$ in.) side drilled hole in the IIW block so that the indication is peaked on the screen. With the increases and decreases in attenuation or gain as shown in the table below, the indication must fall within the limits specified.

Indication Set At *% of full screen height (FSH)*	*dB Control Change*	*Indication Limits* *% of full screen height (FSH)*
80%	-6dB	38 to 42%
80%	-12dB	18 to 22%
40%	+6dB	78 to 82%
20%	+12dB	78 to 82%

Alternative method is to use the dB drop method by adjusting the reference echo to 100% of full screen height (FSH) from back wall (use of a small weight on top of the transducer to get a steady echo is advisable). Reduce the gain by 6 dB and the resulting echo should be 50% of FSH (±1 dB). A further reduction of 6 dB in gain reduces the echo height to 25% of FSH (±1 dB) and a further reduction of 6 dB reduces the echo height to 12.5 % of FSH.

3.7.3 Transducers

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 for adequate penetration or better resolution.

3.7.3(a) Straight Beam Transducer. Straight beam transducer size may vary from 12.5 mm ($^1/_2$ in.) to 25 mm (1 in.) in round or square shape.

Resolution test for the straight beam transducer selected is required by coupling the transducer at position 4 as indicated in Section 3, Figure 1A. Instrumentation range is to be set for minimum 100 mm (4 in.) full scale. Adjust the gain so all three (3) echoes reach full screen height (FSH). Three (3) separate echoes must be displayed.

3.7.3(b) Angle Beam Transducer. The angle beam transducer crystal size may vary from 10.0 mm ($^{13}/_{32}$ in.) to 20 mm ($^3/_4$ in.) in width and length. The transducer may be round, rectangular, or square.

Transducers are to have a nominal frequency of 2.25 or 2.5 MHz. Higher frequencies up to 5 MHz may be utilized for improved resolution or for material of thin cross section. Lower frequencies down to 1 MHz, when agreed to by the Surveyor, may be used for improved signal penetration or for material of heavy cross section (> 19 mm ($^3/_4$ in.)). The transducers are to be affixed to suitable wedges designed to induce refracted shear waves in steel within ±2° of the following angles: 70°, 60° and 45°.

Ultrasonic inspection of materials below 8 mm ($^{5}/_{16}$ in.) in thickness may be specially considered for ultrasonic test. Modified techniques and standards may be required by using smaller angle beam transducer element size (i.e., dimension of elements less than the wall thickness) to maintain a small beam cross section and reduce strong signals associated with boundary effects. See Appendix 2 for guidance.

The transducer and wedge unit are to be clearly marked to indicate the frequency, nominal angle of refraction and the index point. The transducer and wedges are to be checked using the IIW block before use and after each eight (8) hours of use to verify the index point, that the wear face is flat and that the refracted angle is within the ±2° of the proper angle.

The primary consideration for selecting the resulting angle of shear wave is the thickness of the plate. Other factors which may be considered in angle selection are weld joint geometry and groove angle and further evaluation of discontinuities to be detected.

The shear wave angles to be used for various thicknesses are listed below:

Plate Thickness	*Shear Wave Angle**
8 mm ($^{5}/_{16}$ in.) to 19 mm ($^{3}/_{4}$ in.)	70°
Over 19 mm ($^{3}/_{4}$ in.) to 38 mm ($1^{1}/_{2}$ in.)	60°
Over 38 mm ($1^{1}/_{2}$ in.)	45°

* Other shear wave angles may be used provided it is demonstrated that they are suitable for the application involved. For thick plates, consideration for the refracted angle is to provide as near as possible for a perpendicular incident angle on the weld bevel face. For thin plates, the sound path of ultrasonic beam in test material is to be minimized for not greater than 100 mm (4 in.).

Resolution test for the angle beam transducer selected is required by coupling the transducer at an appropriate position for the refracted angle marked on the IIW type RC reference block as shown in Section 3, Figure 1D. Three (3) distinguishable echo signals from the three (3) side-drilled holes must be displayed on A-scan screen.

3.7.4 Couplant

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

3.9 Calibration for Examination

3.9.1 General

The same couplant is to be used for both calibration and field inspection. For contact examination, the temperature differential between the calibration block and examination surfaces shall be within 20°F (12°C). For immersion examination, the couplant temperature for the calibration shall be within 20°F (12°C) of the couplant temperature for examination. Attenuation in couplants, wedge materials and base material varies with temperature and a calibration performed at a given temperature may not be valid for examination at significantly hotter or colder temperatures. The ultrasonic equipment is to be calibrated for horizontal sweep distance and sensitivity with the reference calibration standards just prior to examination each time it is used. Recalibration is to be performed whenever there is a change in examiner (except for automated equipment), after every four (4) hours of continuous use, whenever the power supply to the transmitter has been changed or interrupted, or whenever the calibration of the equipment is suspected of being in error.

The basic calibration block configuration and reflectors are to be as shown in Section 3, Figure 2. The block size and reflector locations shall be adequate to perform calibrations for the beam angles used.

The calibration for examination to detect discontinuities pertinent to the item under inspection is to be demonstrated to the satisfaction of the Surveyor, preferably using samples or reference blocks containing known discontinuities.

3.9.2 DAC Calibration of Angle Beam and Straight Beam

The transducer calibration for straight beam is required to be dual-element (twin-crystal) for steel plate thickness less than or equal to 50 mm (2 in.) or single element if steel plate thickness is greater than 50 mm (2 in.) for both lamination checks and weld inspection, such as Tee and Corner welds to be tested for incomplete penetration from the flat face opposite when accessible.

After determination of weld configuration, plate thickness, and transducer's angle and frequency, ultrasonic sound path can be calculated for horizontal sweep distance. A formula is to be used to calculate the sound path by following:

Sound Path = 2 × Plate Thickness/COS(refracted angle)

A DAC curve is to be established from the responses from the Side drilled holes (SDH) in the appropriate thickness of Basic Calibration Block shown in Section 3, Figure 2.

The following method is used only for instruments without Automatic Distance Amplitude Correction (DAC).

3.9.2(a) DAC of the Basic Calibration Block: Position the search unit for maximum response from the hole which gives the highest amplitude, and adjust the sensitivity control to provide an 80% (±5%) of FSH from the hole. Mark the peak of the indication on the screen.

Without changing the sensitivity control, position the search unit to obtain a maximized response from at least two (2) other reflector holes which cover the calculated maximum sound path distance. Mark the peak of each indication on the screen and connect the points with a smooth line manually or automatically.

3.9.2(b) Amplitude Reject Level (ARL). The DAC from 3/3.9.2(a) represents the DAC curve and serves as the Amplitude Reject Level (ARL).

3.9.2(c) Disregard Level. (DRL). A second DAC curve is to then be plotted from the same reflector holes by dropping gain level by 6 dB. This lower DAC curve serves as the Disregard Level. (DRL)

For instruments with automatic distance amplitude correction, the maximum response from the side drilled holes in the basic calibration block is to be equalized over the appropriate distance range and set at 80% and 40% of full screen height for the (ARL) and (DRL) respectively.

3.11 Weld Inspection

3.11.1 Surface Condition

Surfaces on which the transducer makes contact in the course of weld inspection are to be free from loose scale, loose paint, weld spatter, dirt, other foreign matter or excessive roughness to an extent that allows the transducer intimate contact with the scanning surface. Welds and inspection surface are subject to the requirements from Subsection 1/1.

3.11.2 Plate Lamellar Discontinuities Using Straight Beam Technique

In order to detect lamellar discontinuities in the base plate (i.e., parallel to the surface of the plate) that may be present in way of welds which are to be inspected, the surface adjacent to the weld, on the side or sides where the weld inspection is carried out, is to be inspected by using a straight beam (compressional wave) technique (dual-element if steel plate thickness is less than or equal to 50 mm (2 in.) or single element if steel plate thickness is greater than 50 mm (2 in.)). When these inspections reveal lamellar discontinuities which would interfere with the shear wave weld inspection, the weld inspection is to be made from the opposite side of the weld. If a shear wave ultrasonic inspection cannot be conducted because of laminations on both sides of the weld, the weld location is to be inspected by an alternate nondestructive test technique, such as radiography.

3.11.3 Longitudinal Discontinuities Using Angle Beam Technique

In order to detect longitudinal discontinuities (i.e., along the axis of the weld), the transducer is to be moved in a selected, overlapping pattern similar to that shown in Section 3, Figure 3 (left side of weld). Simultaneously, while moving along the path of inspection and detecting flaw indication, the transducer is to be oscillated through a small angle. The length of weld to be inspected is to be scanned with the transducer directed in two distinct paths: either on both sides of the weld from the same surface, or on opposite surfaces from the same side of the weld.

3.11.4 Transverse Discontinuities Using Angle Beam Technique

In order to detect transverse discontinuities, the transducer is to be angled about 15 degrees from the weld axis and moved parallel to the weld length, as shown in Section 3, Figure 3 (right side of weld). The scan is then to be repeated on the same surface on the other side of the weld if accessible or on opposite surfaces from the same side of the weld. Both scans are to be made with the transducer moved in the same direction. For welds in which the surfaces have been ground, the transducer is placed on the weld surface and moved along the weld axis with the sound beam directed parallel to the weld.

3.11.5 Discontinuity Length Determination

When discontinuities are indicated, the sound beam is to be directed so as to maximize the signal amplitude. The transducer is then moved parallel to the discontinuity and away from the position of maximum signal amplitude until the indication drops toward the base line (6 dB drop). Using the centerline of the wedge of the transducer as an index, the extremity points of the discontinuities are determined as indicated in the following 3/3.11.5(a) and 3/3.11.5 (b):

3.11.5(a) Indications Greater than ARL: For indications with peak amplitudes greater than the ARL, the extremity points of the discontinuity are defined as the points at which the signal drops to 50% of the ARL. (6 db change)

3.11.5(b) Indications Greater than DRL: For indications with peak amplitudes equal to or less than the ARL, the extremity points of the discontinuity are defined as the points where the signal amplitude either remains below the DRL for a distance equal to $^1/_2$ the major dimension of the transducer or drops to $^1/_2$ the peak amplitude, whichever occurs first (i.e., the points which define the shortest discontinuity length).

3.11.6 Adjacent Discontinuity

Adjacent discontinuities separated by less than 2*L* of sound metal (*L* equals length of longest discontinuity) shall be considered as a single discontinuity.

3.13 Ultrasonic Inspection Reports

Ultrasonic inspection reports are to be filed for record and are to include the following items as a minimum:

- Hull number, exact location and length of the welds inspected
- Equipment used (instrument maker, model, and identity; transducer type, identity, size, frequency, and angle)
- Beam angle(s) used
- Couplant used (brand name or type)
- Calibration block identification
- Base metal type and thickness, weld process, surface condition such as any unusual condition of weld bead (ground, undercut, etc.), weld joint design
- Specific acceptance class criteria for examination
- All reflections which are interpreted as failing to meet the specified requirements (as defined in Subsection 3/11 above)
- Dates of inspection and signature of ultrasonic examination operator
- Evaluation of weld(s) examined, evaluation date, name and signature of evaluator

A typical report form, shown in Section 3, Figure 4, is considered acceptable. The method for review and evaluation of ultrasonic test reports is required for adequate quality control and is to be to the satisfaction of the Surveyor.

In case of using PAUT and TOFD, permanent records of all interpretable indications are to be stored electronically (such as on CD-ROM), maintained and retrievable throughout the life of the vessels or structures.

5 Extent of Ultrasonic Inspection

5.1 Checkpoints *(1 February 2012)*

Provision is to be made for the Surveyor to witness the ultrasonic inspection of a representative number of checkpoints. Each checkpoint is to consist of approximately 1250 mm (50 in.) of weld length. However, in cases where extensive production experience has indicated that a high proportion of checkpoints (such as 90 to 95%) are free of non-conforming indications, consideration may be given to reducing the length of checkpoints to 750 mm (30 in.). If the percentage of non-conforming indications rises then a 1250 mm (50 in.) of the length is to be reapplied.

If the number of checkpoints is increased above the minimum required by this Guide, applicable ABS Rules or specified by the Surveyor, then consideration is to be given to reducing the length of each checkpoint to a minimum of 500 mm (20 in.) provided the total weld length checked by ultrasonic testing is at least equivalent to the multiple of 1250 mm (50 in.) × the minimum required number of checkpoints,. Reduction in ultrasonic inspection length to 500 mm (20 in.), as indicated above, is subject to prior agreement of the Owner.

Lengths of welds inspected at subassembly stage and final erection stage (as required under 3/7.1.1 below) may be combined to form a single checkpoint (of 1250 mm (50 in.) as appropriate). If the proportion of non-conforming indications is abnormally high, the number of checkpoints is to be increased.

5.3 Ship-Type Vessels *(1 February 2012)*

The minimum checkpoints of inspection within the midship 0.6L of ship-type vessels are to be governed by the following equation:

$n = L(B + D)/46.5$ SI and MKS units $\qquad$ $n = L(B + D)/500$ US units

where

n	=	minimum number of checkpoints
L	=	length of the vessel between perpendiculars, in m (ft)
B	=	greatest molded breadth, in m (ft)
D	=	molded depth at the side, in m (ft), measured at $L/2$

Consideration may be given for reduction of inspection frequency for automated welds for which quality assurance techniques indicate consistent satisfactory quality.

5.5 Other Marine and Offshore Structures *(1 September 2011)*

The extent of ultrasonic inspection for other marine and offshore structures is to be governed by the applicable Rule requirements (e.g., ABS *Rules for Building and Classing Mobile Offshore Drilling Units*).

7 Location of Ultrasonic Inspection

7.1 General

(1 September 2011) In selecting checkpoints the following should be given emphasis in the selection of inspection locations:

i) Welds in highly stressed areas

ii) Welds, which are inaccessible or very difficult to inspect in service

iii) Field erected welds

iv) Suspected problem areas

v) Other important structural elements, which are required by the ABS Engineering/Materials/Survey department

7.1.1 Surface Vessels

Ultrasonic inspection within the midship 0.6*L* is to be carried out mainly in locations such as:

i) Intersections of butts and seams in the sheer strakes, bilge strakes, deck stringer plates and keel plates

ii) Intersections of butts in and about hatch corners in main decks

iii) In the vicinity of breaks in the superstructure

Ultrasonic inspection outside the midship 0.6*L* is to be carried out at random in important locations, such as those specified above, at the discretion of the Surveyor. Where inspection is to be carried out at weld intersections, in general a minimum of 250 mm (10 in.) of weld, measured from the intersection in each direction transverse to the axis of the vessel (butt weld), is to be inspected. In addition, a minimum of 125 mm (5 in.) of weld, measured from the intersection in each direction longitudinal to the axis of the vessel (seam weld), is to be inspected.

7.1.2 Other Marine and Offshore Structures *(1 September 2011)*

Ultrasonic inspection is to be carried out at locations specified in the approved plans and by the Rules applicable to the structure, (e.g., ABS *Rules for Building and Classing Mobile Offshore Drilling Units*).

9 Acceptance Criteria for Ultrasonic Inspection *(1 September 2011)*

9.1 Applicability

The acceptance standards of Section 8 are applicable for full penetration butt welds in locations where ultrasonic inspection is carried out in accordance with this Guide and where required by the Surveyor and are not intended to apply to supplementary inspections conducted beyond Rule requirements.

11 Treatment of Welds with Non-conforming Indications

11.1 General

All non-conforming ultrasonic indications are to be brought to the attention of the Surveyor and welds are to be repaired and re-inspected as required by the Surveyor.

11.3 Discontinuity Extent

11.3.1 At One Location

Unless otherwise required by the Surveyor, when non-conforming indications are concentrated at one location, only this location need be repaired or otherwise treated to the satisfaction of the Surveyor, and no additional ultrasonic inspection need be carried out in the adjacent area.

11.3.2 At the End of a Checkpoint

When non-conforming indications are observed at the end of a checkpoint, additional ultrasonic inspection is required to determine the extent of the non-conforming area.

11.3.3 Additional Inspection

When a series of non-conforming indications are observed at a checkpoint and the pattern of the indications suggests that non-conforming discontinuities may exist for an extended distance, additional inspection is to be carried out to the satisfaction of the Surveyor.

13 Ultrasonic Inspection of Full Penetration Tee and Corner Joints

When required by the applicable Rules or in the course of a periodic or damage survey, the acceptance standards are to be consistent with the guidance of Appendix 2.

15 References *(1 September 2011)*

i) ASTM E164, *Standard Practice for Ultrasonic Contact Examination of Weldments*.

ii) ASTM E 797, *Standard Practice for Measuring Thickness by Manual Ultrasonic Pulse-Echo Contact Method.*

iii) ASTM A 435/A 435M-90 (Reapproved 2007), *Standard Specification for Straight-beam Ultrasonic Examination of Steel Plates*.

FIGURE 1A
IIW Reference Block Type US-1 *(1 September 2011)*

IIW Reference Block Type US-1, used for calibration of shear and longitudinal transducers, and verification of shear wedge exit point and refracted angle. It can also be used for resolution and sensitivity checking.

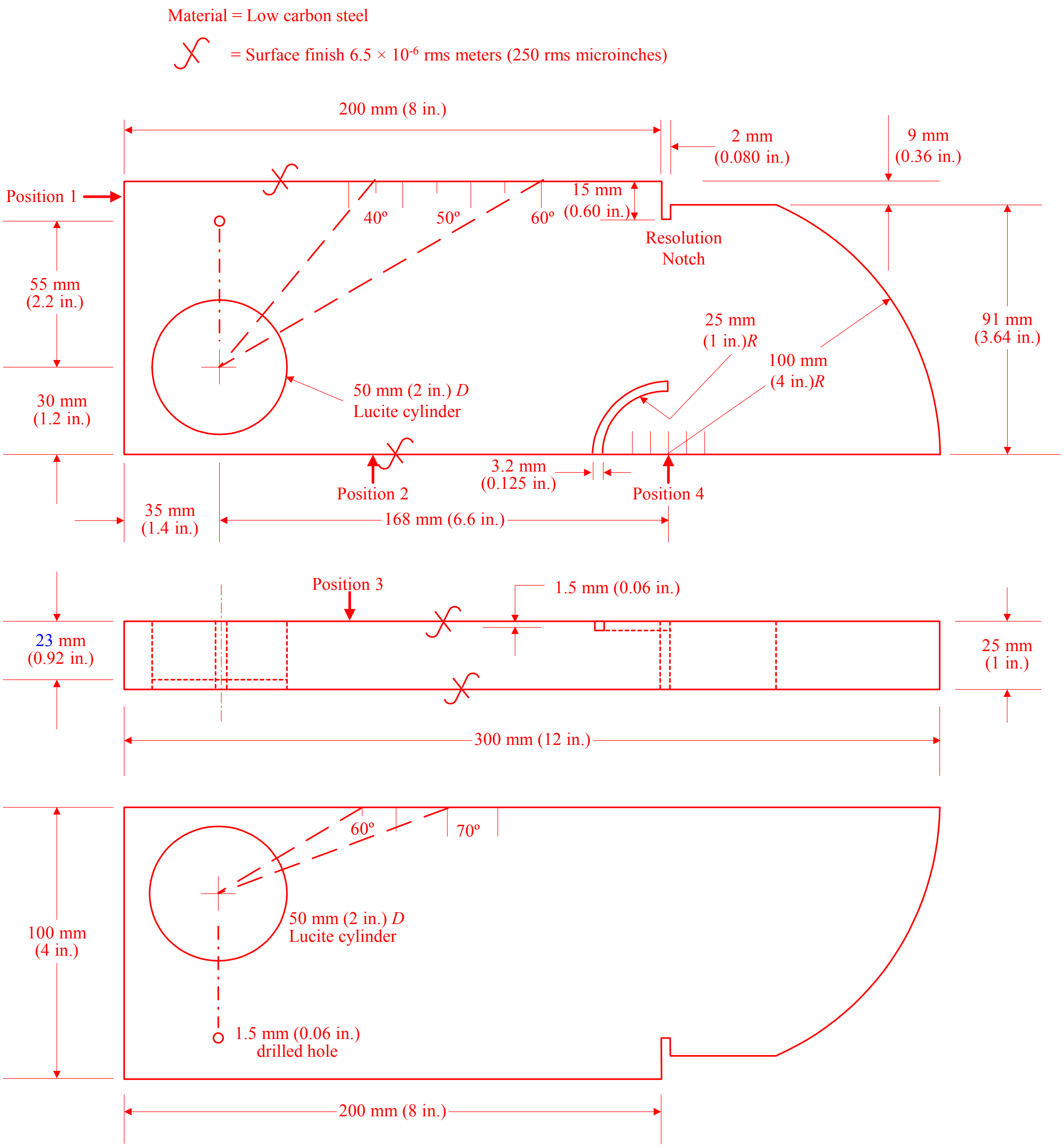


FIGURE 1B
Type MAB Miniature Angle-Beam Reference Block *(1 September 2011)*

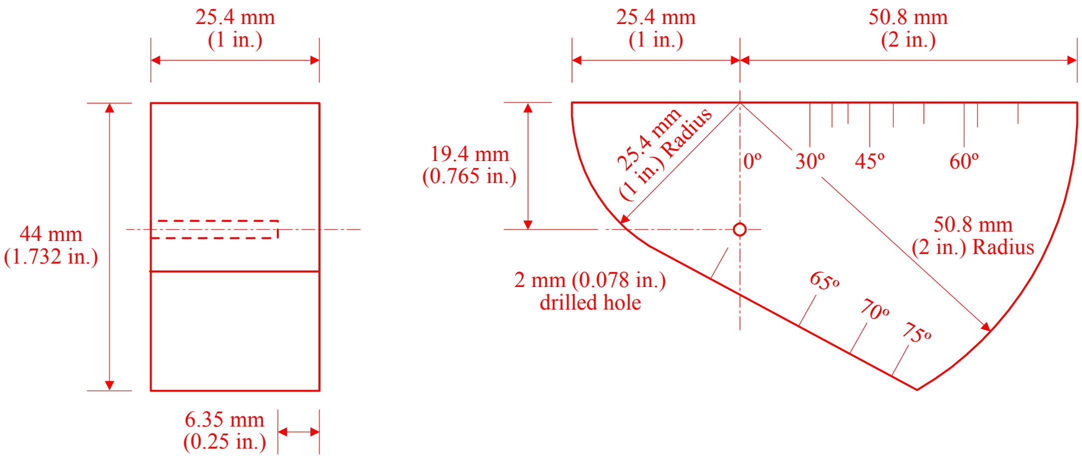


FIGURE 1C
Type DSC Distance and Sensitivity Reference Block *(1 September 2011)*

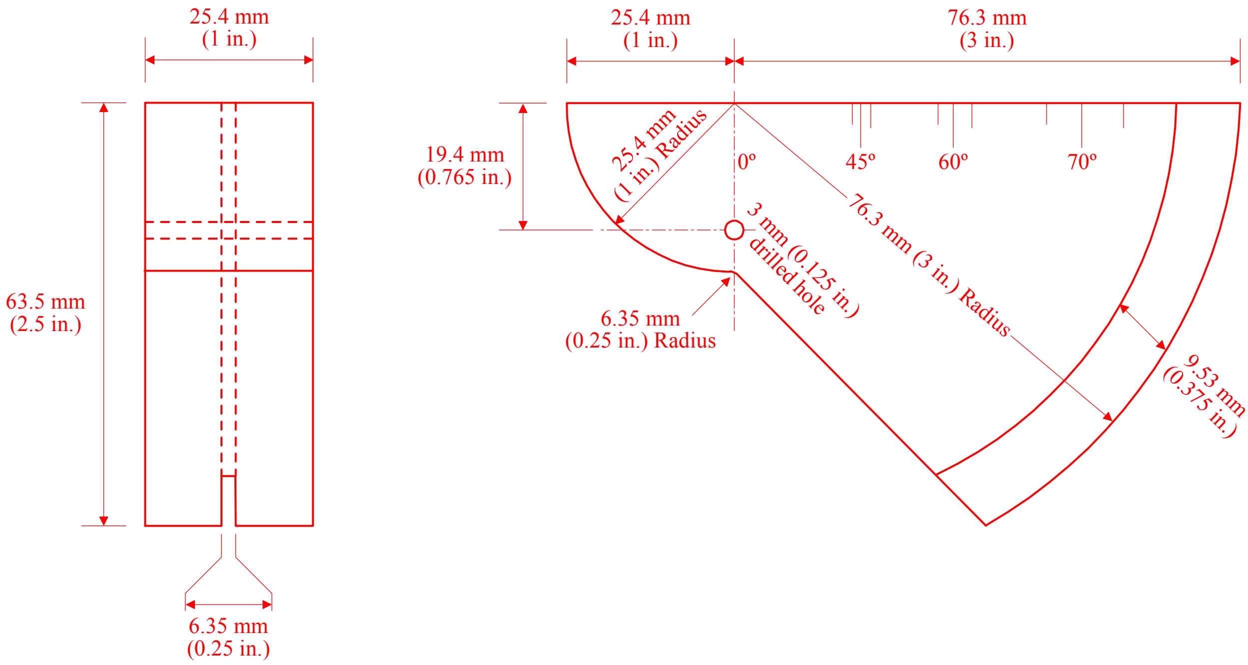


FIGURE 1D
IIW Type RC Reference Block *(1 September 2011)*

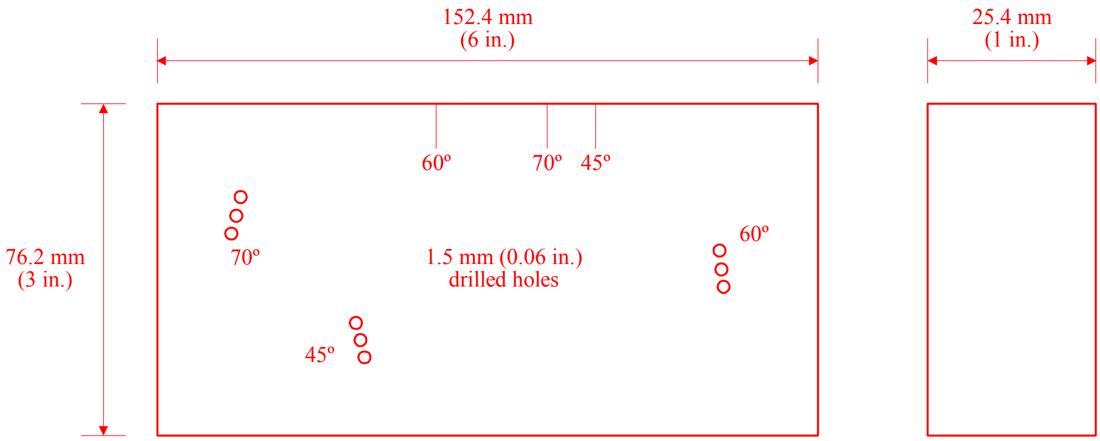
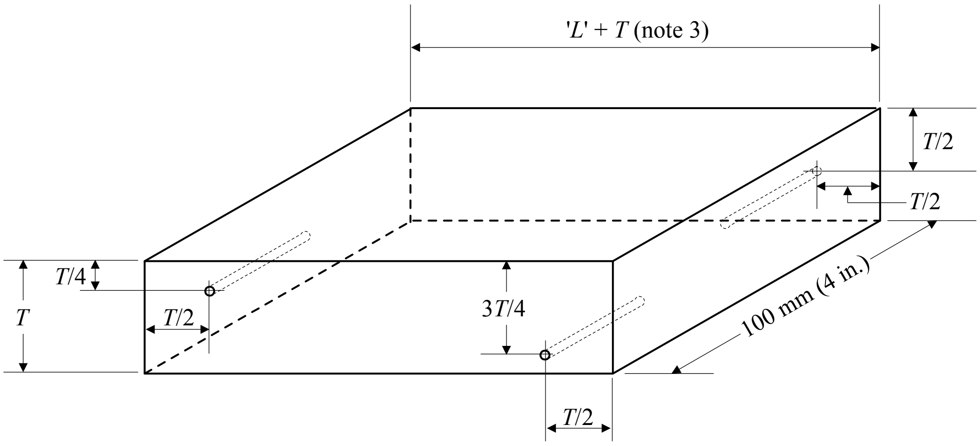


FIGURE 2
Basic Calibration Block

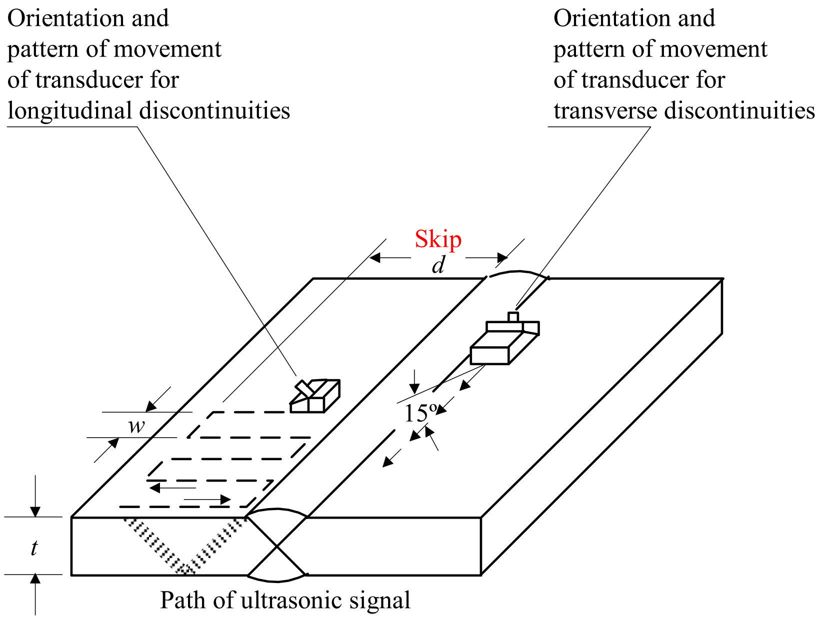


<u>**Weld Joint Thickness**</u>	<u>**Basic Calibration Block Thickness**</u>
25 mm (1 in.) or less	19 mm (0.75 in.) or *T*
Greater than 25 mm (1 in) to 50 mm (2 in.)	38 mm (1.5 in.) or *T*
Greater than 50 mm (2 in) to 100 mm (4 in.)	75 mm (3 in.) or *T*
Greater than 100 mm (4 in) to 150 mm (6 in.)	125 mm (5 in.) or *T*

<u>**Calibration Block Requirements**</u>

1. Material to be on same product form and heat treatment as the material to be inspected.
2. Surface finish from which the scanning is to be conducted is to be representative of the component to be inspected.
3. '*L*' shall be sufficient to allow a minimum of two half skips (one vee path) of the sound beam using the transducer angle to be used. '*T*' is thickness of the weld joint to be examined.
4. Calibration Reflector Holes to be drilled parallel to the scanning surface.
5. Calibration Reflector Holes to be 1.2 mm (0.047 (3/64) in.) diameter × 38 mm (1.5 in.) deep.

FIGURE 3
Scanning Procedure for Welds not Ground Flush *(1 September 2011)*



w - is to be less than 90% of transducer crystal width (10% overlap)
t - material thickness
θ - transducer shear wave angle
d - >2*t*(tan θ) + 3.2 mm (0.125 (1/8) in.)

FIGURE 4
Typical Ultrasonic Report Form *(1 September 2011)*

REPORT NO. ______________________

1. Hull No.______________________ 2. Location ____

3. Equipment

   a. Transducer ______________ ______________ ______________

      Identification Size Wedge Angle Freq. (MHz)

   b. Instrument Maker and Model ____

   c. Couplant: Brand Name & Type ____

4. Acceptance Criteria: ____________________________(ABS Class A / Class B / Other)

5. Weld Details

Base Metal	Thickness(es)	Weld Process	Surface Appearance

6. Weld Joint Design (Describe & Sketch to be attached):

7. Unacceptable Indications*

Location	Reject Rationale ARL/DRL/M-DRL	Amplitude	Length	Height	Orientation	Type of Indication (i.e., crack, slag, non-fusion,…)

8. Total Number Indications: ____________________. Total Length Indications:____________________ .

9. Total Length Inspected ____.

10 **Inspected by** ____ Date ___________

Comments ____.

11 **Reviewed by** ____ Date ___________

Comments ____.

12 Repairs – Completed and Approved _______________, ______________________________

(as per 3/13) Date Name

____

Title

* Appropriate sketches may be used as alternates or supplements to 7

SECTION 4 Liquid Penetrant

1 General

The requirements contained herein are primarily intended for liquid penetrant surface inspection of welds in hull structures of surface vessels. These requirements are intended to apply to full and partial penetration welds of steel and aluminum alloys.

3 Surface Condition

3.1 General *(1 September 2011)*

The inside and outside surfaces of the welds to be inspected by liquid penetrant are to be sufficiently free from irregularities that may mask or interfere with interpretation.

The surface to be inspected is to be thoroughly cleaned and degreased so that there are no contaminants and entrapped materials that impede penetration of the inspection media.

3.3 Cause for Rejection

Surface conditions that prevent proper interpretation of welds may be cause for rejection of the weld area of interest.

5 Liquid Penetrant Procedure

5.1 General

A liquid penetrant, which may be a visible red liquid or a fluorescent yellow-green liquid, is applied evenly over the surface being examined and allowed to enter open discontinuities. After a suitable dwell time, the excess surface penetrant is removed. A developer is applied to draw the entrapped penetrant out of the discontinuity and stain the developer. The test surface is then examined to determine the presence or absence of indications.

5.3 Personnel *(1 September 2011)*

The Surveyor is to be satisfied that NDT personnel are qualified and certified in accordance with Subsection 1/5.

5.5 Technique *(1 September 2011)*

Steel and aluminum welds are to be inspected by either the visible or fluorescent solvent removable method.

Water-washable and post-emulsifiable penetrant methods are not recommended due to the strict requirements for water pressure and water temperature control.

The temperature of the penetrant and the surface to be inspected shall not be below 5°C (40°F) nor above 52°C (125°F) throughout the examination period. Local heating or cooling is permitted provided the surface part temperature remains in the range of 5°C (40°F) to 52°C (125°F) 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 and to the satisfaction of the Surveyor.

5.7 Procedure

Visible or fluorescent penetrant is to be applied to the inspection surface by spraying or brushing.

5.7.1 *(1 September 2011)*

A minimum dwell time (penetration time) of 5 minutes or time recommended by manufacturer is to be used. A longer dwell time is to be used for the detection of fine tight discontinuities. The minimum dwell penetration time shall be doubled when temperature is from 5°C (40°F) to 10°C (50°F).

5.7.2

At the completion of the applicable dwell time, removal of the excess surface penetrant is to be with lint-free material moistened with solvent remover.

i) Solvent remover is not to be sprayed directly onto the inspection surface.

ii) Sufficient time is to be allowed for the solvent to evaporate from the inspection surface.

5.7.3 *(1 September 2011)*

A thin coating of non-aqueous developer is to be applied by spraying the inspection surface from a minimum distance of 300 mm (12 in.) as soon as possible after penetrant removal.

i) A minimum developing time of 10 minutes, or twice the dwell time, whichever is greater, is to be used.

ii) Developing time is to commence as soon as the non-aqueous developer is dry.

iii) Developing time is not to exceed 60 minutes.

7 Examination

7.1 General

Preliminary examination of the inspection area may be carried out during the developing time. An indication that appears quickly would indicate a large discontinuity and, if not observed, may result in a diffused stain rather than a sharp indication after the full dwell time.

7.3 Final Examination *(1 September 2011)*

Final examination is to be made within 10 to 60 minutes at the completion of the applicable developing time as soon as possible after evaporation of solvent remover. 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.

7.5 Visible Penetrant Examination

7.5.1

The visible penetrant is generally red in color and thus provides a high degree of contrast against the white developer.

7.5.2

A minimum light intensity of 1000 Lux (100 foot candles) at the inspection surface is to be obtained.

i) Either natural or artificial light is acceptable.

ii) Demonstration of the minimum light intensity is to be to the satisfaction of the Surveyor.

iii) A calibrated photographic-type light meter is to be used to verify the required minimum intensity.

iv) Calibration of the light meter is to be performed and documented every 6 months.

v) The calibration standard is to be traceable to the National Institute of Standards and Testing (NIST).

vi) Other recognized standards may be acceptable subject to the satisfaction of the Surveyor.

7.7 Fluorescent Penetrant Examination

7.7.1

The penetrant fluoresces when examined by ultraviolet (U/V) light. Fluorescent penetrant inspection provides the highest sensitivity level. Inspection by U/V light requires a darkened area for examination.

7.7.2

Visible ambient light in the darkened inspection area is not to exceed 20 Lux (2 foot candles).

i) Before commencing inspection, a minimum period of 3 minutes is to be observed by the inspector to allow for the eyes to adapt to the lower light level.

ii) Photochromic lenses are not to be worn by the inspector during the inspection.

7.7.3

The U/V light is to be capable of providing a minimum intensity of 1000 $\mu W/cm^2$ at the inspection surface.

7.7.4

The U/V light is to have a minimum of 10 minutes to stabilize before inspection or measurement of the required minimum U/V light intensity.

i) The intensity of the U/V light is to be verified weekly.

ii) Demonstration of the minimum U/V light intensity is to be to the satisfaction of the Surveyor.

iii) A calibrated U/V light meter is to be used to verify the required minimum intensity.

iv) Calibration of the U/V light meter is to be performed and documented every 6 months.

v) The calibration standard is to be traceable to the National Institute of Standards and Testing (NIST).

vi) Other recognized standards may be acceptable subject to the satisfaction of the Surveyor.

9 Extent of Liquid Penetrant Inspection *(1 September 2011)*

The extent of liquid penetrant surface inspection is to be in accordance with the approval plans, applicable ABS Rules and to the satisfaction of the Surveyor.

11 Acceptance Criteria for Liquid Penetrant Inspection *(1 September 2011)*

The acceptance standards of Section 8 are applicable for all welds inspected by this method.

13 Treatment of Welds with Non-conforming Indications

13.1 General

Welds exhibiting non-conforming indications are to be brought to the attention of the Surveyor. Such welds are to be repaired and inspected as required by the Surveyor.

15 Post-Cleaning

Removal of penetrant and developer shall be by non-aqueous solvent.

i) It is permissible to spray the non-aqueous solvent directly onto the inspection area at this stage.

ii) Mechanical/abrasive methods are not to be used.

17 References *(1 September 2011)*

i) American Welding Society (AWS), D1.1, *Structural Welding Code, Steel*.

ii) ASTM E165, *Standard Test Method for Liquid Penetrant Examination*.

iii) ASME Boiler and Pressure Vessel Code, Section V – *Nondestructive Examination*

SECTION 5 Magnetic Particle

1 General

The requirements contained herein are primarily intended for magnetic particle surface inspection of welds in hull structures of surface vessels. These requirements are intended to apply to full and partial penetration welds of ferromagnetic steel.

3 Surface Condition

3.1 General

The inside and outside surfaces of the welds to be inspected by magnetic particle are to be sufficiently free from irregularities that may mask or interfere with interpretation.

3.3 Cause for Rejection

Surface conditions that prevent proper interpretation of welds may be cause for rejection of the weld area of interest.

5 Magnetic Particle Procedure

5.1 General *(1 September 2011)*

When a ferromagnetic material is magnetized, surface-breaking discontinuities may cause the induced magnetic flux to attract fine magnetic particles to the discontinuity site. The accumulated particles are to be viewed under adequate lighting in order to show the visual indication of the length and width of the discontinuity.

5.3 Personnel *(1 September 2011)*

The Surveyor is to be satisfied that NDT personnel are qualified and certified in accordance with Subsection 1/5.

5.5 Technique

Steel welds are to be inspected by either the visible or fluorescent particle method.

5.5.1 *(1 September 2011)*

The visible method may be performed with either wet or dry particles. Wet particle method is recommended for fine tight cracks.

5.5.2

If a surface-breaking discontinuity is oriented parallel to the magnetic flux, it may not provide an indication. The sharpest indication may be obtained when the magnetic flux is perpendicular to the discontinuity.

i) The area of interest is to be inspected in at least two (2) directions.

ii) Each direction is to be perpendicular to the other.

5.7 Equipment *(1 September 2011)*

5.7.1 General

The equipment used to generate magnetic flux for in-situ inspection in the marine environment may be either an electromagnetic yoke or permanent magnets. Both devices provide portability and simplicity of use.

- A yoke is a hand-held U-shaped electromagnet, which produces a longitudinal magnetic flux between the legs. The legs may be fixed or articulated.
- A permanent magnet may be U-shaped, with a fixed distance between the legs. A variation is that a permanent magnet may consist of two (2) magnets connected by flexible steel cable.

5.7.2 Magnetic Field Strength

i) When using an electromagnetic yoke or permanent magnet, adequate field strength is to be considered acceptable by lifting a calibrated test bar.

ii) The weight of the test bar is to be

- 4.5 kgs (10 lbs.) for an AC yoke
- 18 kgs (40 lbs.) for a DC yoke or a permanent magnet

iii) The calibration weight of the test bar is to be traceable to the National Institute of Standards and Testing (NIST). Other recognized standards may be acceptable subject to the satisfaction of the Surveyor. The test bar is to be permanently marked with a unique serial number and actual weight.

iv) Additional verification of the magnetic field strength is to be demonstrated by the detection of known artificial discontinuities in a magnetic field indicator.

- The "pie" gauge and slotted shim are acceptable examples of a magnetic field indicator.
- Magnetic field strength is to be considered acceptable when the artificial discontinuities are clearly observed between the legs of the electromagnetic yoke or permanent magnet.
- Both the lift test and artificial discontinuities test are to be performed at the beginning and completion of each inspection day.

5.7.3 Visible Magnetic Particles

Visible magnetic particle inspection may be performed with dry powders or wet contrasting inks.

i) Dry powders are to be applied by gently dusting the inspection area while the magnetizing flux is generated.

ii) Examination of the inspection area is to be performed as the magnetic flux is still being generated.

iii) The contrasting ink technique consists of a white lacquer under suspension, and is to be applied by spraying. The magnetic particles are suspended in black ink and are also to be applied by spraying.

- The white lacquer and black ink are to be applied by spraying the inspection surface from a minimum distance of 300 mm (12 in.).
- The black ink is only to be applied when the white lacquer is fully dry. If the black ink is not in pressured spray can, a sitting test shall be performed on each batch when mixed. Concentration shall be between 1.2 and 2.4 per 180 ml.

5.7.4 Fluorescent Magnetic Particles

Magnetic particles are coated with a fluorescent material suspended in a light petroleum distillate and held under pressure in small spray cans. The fluorescent particles are to be applied by spraying the inspection surface from a minimum distance of 300 mm (12 in.).

5.7.5 Examination

Examination of the inspection area is to be performed as the magnetic flux is being generated. Examination, interpretation and evaluation of indications are to be performed by qualified and certified Level II or Level III magnetic particle inspectors.

5.9 Visible Particle Inspection

5.9.1

Colored dry powder particles provide contrast with the inspection surface. A higher level of contrast is obtained with the use of the white and black ink particles.

5.9.2

A minimum light intensity of 1000 Lux (100 foot candles) at the inspection surface is to be obtained.

i) Either natural or artificial light is acceptable.

ii) Demonstration of the minimum light intensity is to be to the satisfaction of the Surveyor.

iii) A calibrated photographic-type light meter is to be used to verify the required minimum intensity.

iv) Calibration of the light meter is to be performed and documented every 6 months.

v) The calibration standard is to be traceable to the National Institute of Standards and Testing (NIST).

vi) Other recognized standards may be acceptable subject to the satisfaction of the Surveyor.

5.11 Fluorescent Particle Inspection

5.11.1

The fluorescent particles fluoresce when examined by ultraviolet (U/V) light and provide the highest level of sensitivity. Inspection by U/V light requires a darkened area for examination.

5.11.2

Visible ambient light in the darkened inspection area is not to exceed 20 Lux (2 foot candles).

i) Before commencing inspection, a minimum period of 3 minutes is to be observed by the inspector to allow for the eyes to adapt to the lower light level.

ii) Photochromic lenses are not to be worn by the inspector during the inspection.

5.11.3

The U/V light is to be capable of providing a minimum intensity of 1000 $\mu W/cm^2$ at the inspection surface.

5.11.4

The U/V light is to have a minimum of 10 minutes to stabilize before inspection or measurement of the required minimum U/V light intensity.

i) The intensity of the U/V light is to be verified weekly.

ii) Demonstration of the minimum U/V light intensity is to be to the satisfaction of the Surveyor.

iii) A calibrated ultraviolet light meter is to be used to verify the required minimum intensity.

iv) Calibration of the U/V light meter is to be performed and documented every 6 months.

v) The calibration standard is to be traceable to the National Institute of Standards and Testing (NIST).

vi) Other recognized standards may be acceptable subject to the satisfaction of the Surveyor.

7 Extent of Magnetic Particle Inspection *(1 September 2011)*

The extent of magnetic particle surface inspection is to be in accordance with the approval plans, applicable ABS Rules and to the satisfaction of the Surveyor.

9 Acceptance Criteria for Magnetic Particle Inspection *(1 September 2011)*

The acceptance standards of Section 8 are applicable for all welds inspected by this method.

11 Treatment of Welds with Non-conforming Indications

11.1 General

Welds exhibiting non-conforming indications are to be brought to the attention of the Surveyor. Such welds are to be repaired and inspected as required by the Surveyor.

13 Demagnetization

13.1

Demagnetization is to be required if any of the following operations are to be performed in the inspection area:

- Welding
- Painting
- Plating

13.1.1

Demagnetization is to be required if the inspection area is in close proximity to sensitive electronic instrumentation or a compass.

13.1.2

Demagnetization is to be performed by a sufficient number of passes over the inspection area by an energized electromagnetic yoke.

13.3

After demagnetization, any remaining residual magnetism is not to exceed 3 Gauss (240 Am^{-1}). Verification of the level of residual magnetism is to be performed with a calibrated residual field meter.

15 Post-cleaning

Post-cleaning of the inspection area is to be required if any of the following operations are to be performed:

- Welding
- Painting
- Plating

Post-cleaning is to be completed with the use of compressed air, brushing, or solvent cleaning.

17 References

i) American Welding Society (AWS), D1.1, *Structural Welding Code, Steel*.

ii) ASTM E709, *Standard Guide for Magnetic Particle Examination*.

SECTION 6 Alternating Current Field Measurement Technique (ACFMT) *(1 September 2011)*

1 General

The requirements contained herein are primarily intended for the surface inspection of hull structures of surface vessels and, when indicated by ABS, may also be applied to other marine and offshore structures. These requirements are intended to apply to the welds of steel and aluminum alloys.

3 Surface Condition

The system operator is to confirm that the surface condition is acceptable prior to carrying out the inspection.

3.1

The surface is to be free of loose flaking corrosion and in clean condition to allow smooth probe travel.

3.3

Coating removal is not required as long as it is not more than 6.5 mm (0.25 ($^1/_4$) in.) thick and non-conducting.

3.5

The surface being inspected is to be in an unmagnetized state. If the procedure is to be conducted after any previous magnetic inspection technique, demagnetization of the surface is to be carried out.

5 ACFMT Testing Procedure

5.1 Personnel

The Surveyor is to be satisfied that NDT personnel are qualified and certified in accordance with Subsection 1/5.

7 Technique

7.1 General

The capability of equipment calibrated to detect discontinuities pertinent to the item under inspection is to be demonstrated to the satisfaction of the Surveyor, preferably using samples containing known discontinuities.

7.3 Calibration

7.3.1

The equipment and probes to be used are to be calibrated prior to the examination of the first weld using samples containing known discontinuities.

7.3.2

Each combination of ACFMT unit and probe to be used during the examination is to be used with the operations check block.

7.3.3

Results obtained with the combinations used are to be the same as the slots in the block. If they differ by 10%, a check is to be performed that the correct probe files and gain have been used. Recalibration is to be performed until the correct results are obtained.

7.3.4

System performance is to be verified every four hours with the probe in use or at the end of the examination being performed.

7.3.5

If the flaw responses from the operations check block have changed substantially, the welds examined since the last operations check block verification are to be re-examined.

7.3.6

The ACFMT equipment is to be re-calibrated every 12 months by the manufacturer.

9 Capability and Performance Check of the Equipment

9.1 Instrument Settings

The procedure in 6/9.3 below is intended to help the user select an operating frequency. Demonstrably equivalent methods may be used. The standard operating frequency is 5 kHz, but depending on the type of equipment being used, higher or lower operating frequencies are available. A higher operating frequency gives better sensitivity on good surfaces, while a lower operating frequency may allow detection of sub-surface defects in non-magnetic metals. If the system available for inspection is not capable of operating at the frequency described by this practice, the inspector is to declare to the Surveyor that conditions of reduced sensitivity may exist.

9.3 Equipment Performance Check

The test system is to consist of an ACFMT crack microgauge, a PC, the probe and the operation check block.

9.3.1

The equipment performance check is to be performed using the appropriate operation check block containing slots of 50 × 5 mm^2 (2.0 × 0.2 in^2) and 20 × 2 mm^2 (0.8 × 0.08 in^2).

9.3.2

The probe is to be placed at the toe of the weld with the nose of the probe parallel to the longitudinal direction of the weld.

9.3.3

The probe is then to be scanned across the operation check block and over the 50 × 5 mm^2 (2.0 × 0.2 in^2) slot, producing a standardized data plot.

9.3.4

Flaw indications are created when:

- The background level B_x value is reduced and then returns to the nominal background level (Figure 1), and this is associated with
- A peak or positive (+ve) indication, followed by a trough or negative (–ve) indication (or a trough followed by a peak, depending on direction of scan) in the B_z values.

9.3.5

The resultant effect of the changes in B_x and B_z is a downward loop in the X-Y plot (Section 6, Figure 1).

9.3.6

The presence of a flaw is confirmed when all three of these indications are present, (i.e., the B_x, the B_z and a downward loop in the X-Y plot). The loop is to fill approximately 50% of the height and 175% of the width of the X-Y plot.

9.3.7

The scanning speed or data sampling rate can then be adjusted if necessary, depending on the length and complexity of weld to be examined.

9.3.8

Once the presence of the flaw has been confirmed by the B_x and B_z indications, the flaw is to be sized.

9.5 Flaw Sizing

Flaw sizing is based upon the use of mathematical models constructed to simulate the current flow around defects and the changes in surface magnetic field which would result. The model is run for a large number of discrete defects with various lengths and depths, and the results of the model are used to compile look-up tables of expected response versus defect sized. These tables are an integral part of the inspection software. The operator enters background and minimum values of B_x, along with the B_x length and any coating thickness, to allow the software to predict length and depth.

The results from the model are to be rigorously checked against a library of real defects to confirm the validity of the sizing tables.

9.7 Instrument and Probe Settings Check

If these values differ from those expected from the operation check block, then the instrument and probe settings are to be checked.

Each probe has a unique probe file, the validity of which has been checked against the flaw sizing tables in the mathematical model. The instrument settings can be checked using the same software package.

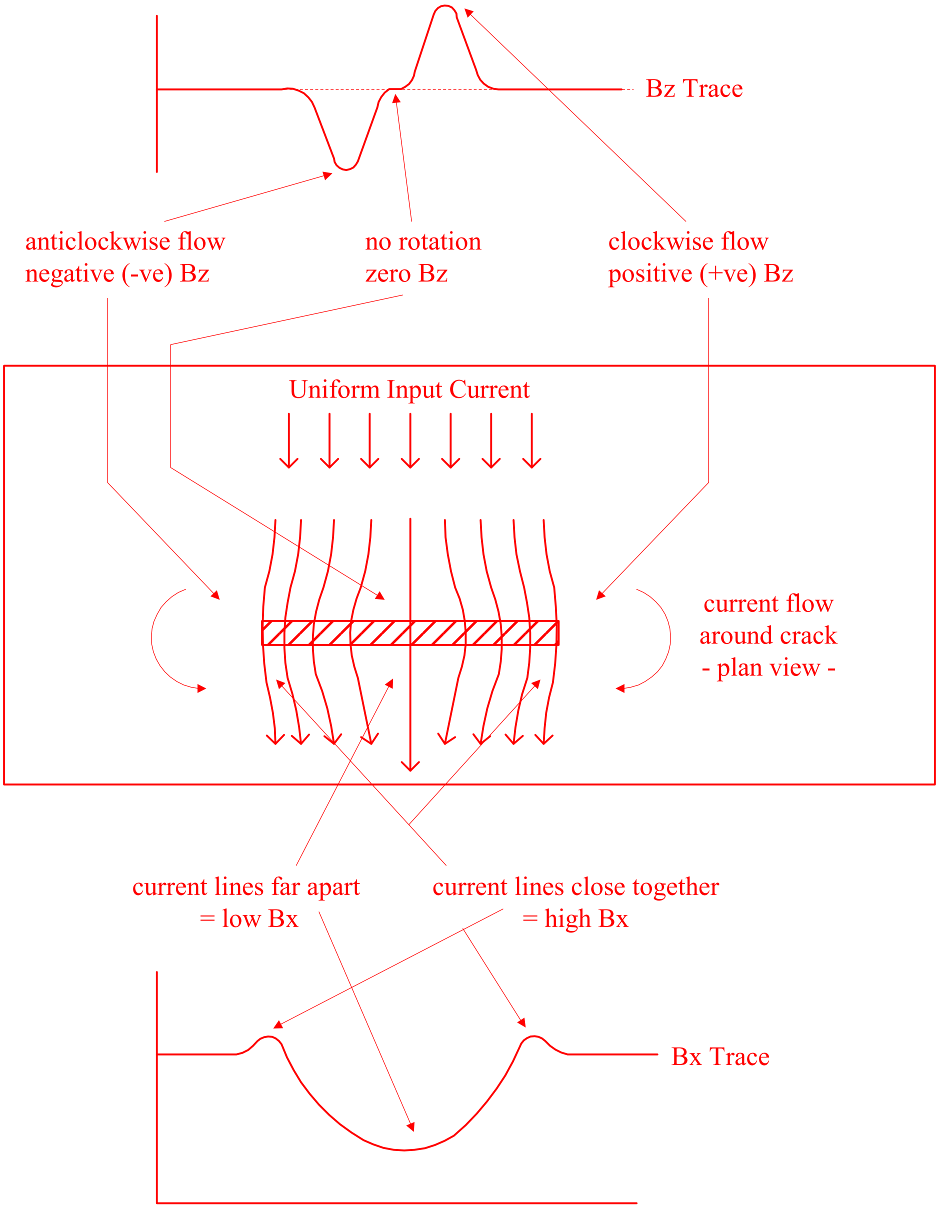
11 Extent of ACFMT Inspection

The extent of ACFMT inspection is to be in accordance with the approval plans, applicable ABS Rules and to the satisfaction of the Surveyor.

13 References

i) ASTM E2261 *Standard Practice for Examination of Welds Using the Alternating Current Field Measurement Technique*

FIGURE 1
Example Bx and Bz Traces as a Probe Passes Over a Crack



SECTION 7 Eddy Current (EC) Inspection

SECTION 7 Eddy Current (EC) Inspection

1 General *(1 September 2011)*

The requirements contained herein are primarily intended for the surface inspection of hull structures of surface vessels and, when indicated by ABS, may also be applied to other marine and offshore structures. These requirements are intended to apply to the welds of steel and aluminum alloys.

3 Surface Condition

The system operator is to confirm that the surface condition is acceptable prior to carrying out the inspection.

3.1

The inspection surface is to be free of dirt, flaking paint, excessive corrosion, or any contaminants which may interfere with the test results.

3.3

Coating removal is not required providing that it can be demonstrated that the discontinuities sought can be detected under these conditions. This may involve coating the reference specimen with a similar coating during calibration.

5 EC Testing Procedure

5.1 Personnel *(1 September 2011)*

The Surveyor is to be satisfied that NDT personnel are qualified and certified in accordance with Subsection 1/5.

7 Technique

7.1 General

The capability of equipment calibrated to detect discontinuities pertinent to the item under inspection is to be demonstrated to the satisfaction of the Surveyor, preferably using samples containing known discontinuities.

7.3 Calibration

EC Probes (Transducers) of sufficient diameter and frequency range are to be used.

7.3.1

A diameter of EC Probes less than 3.2 mm ($^1/_8$ in.) and a frequency range between 100 kHz – 2 MHz are acceptable for surface crack detection.

7.3.2 *(1 September 2011)*

The area of influence for each scan is to be restricted to an area of less than 3.2 mm ($^1/_8$ in.) width. Therefore, many scans in a raster scan pattern are to be required for full coverage.

7.3.3

The equipment and probes to be used are to be calibrated prior to the examination of the first weld using samples containing known discontinuities.

7.3.4

System performance is to be verified every 30 minutes with the probe in use and at the end of the examination being performed.

7.3.5

If the system performance calibration has changed, the welds examined since calibration are to be re-examined.

7.3.6

The EC equipment is to be re-calibrated every 12 months by the manufacturer.

9 EC Application

9.1

A high frequency oscillator circuit produces alternating current in the range typically of 100Hz – 10 MHz and is applied to a small coil. The alternating current flowing through the coil generates an alternating magnetic field around the coil.

9.3

When the alternating magnetic field is in close proximity to an electrically conductive material (the test item) a secondary electrical current is to be created in the test item due to electromagnetic induction. The distribution of the current will be determined by the test settings and material properties. The secondary electrical current will generate its own magnetic field which will interact with the magnetic field of the coil and modify it. The shape and magnitude of the secondary field will be determined by the secondary current induced into the specimen.

9.5

The secondary magnetic field will also modify the primary current flowing through the coil by changing the impedance of the coil. The change in impedance can be detected using sensitive bridge circuitry within the eddy current set. When the test settings are maintained constant during the test, the only changes in the impedance of the coil will be due to changing material properties.

9.7

If reference specimens are available with varying degrees of the anomaly present the EC instrument can be calibrated to detect and quantify the condition of the inspection material.

11 Extent of EC Inspection

The extent of EC inspection is to be in accordance with the approval plans, applicable ABS Rules and to the satisfaction of the Surveyor.

13 References *(1 September 2011)*

i) ASTM E 376, *Standard Practice for Measuring Coating Thickness by Magnetic-field or Eddy Current (Electromagnetic) Examination Methods*.

SECTION 8 Acceptance Criteria for Hull Welds

1 General *(1 September 2011)*

This Section contains the acceptance criteria for use in the visual and NDT inspection of Hull welds.

The system operator is to confirm that the surface condition is acceptable prior to carrying out the inspection.

3 Applicable Criteria *(1 September 2011)*

3.1 Surface Vessels – Class A Criteria

Inspection of full penetration welds for all surface vessels 150 m (500 ft) and over, in the midship 0.6*L* is to meet the requirements of Class A. Class A may also be specified and applied to surface vessels less than 150 m (500 ft) when special hull material or hull design justifies this severity level.

Full penetration welds in way of integral or independent tanks, except membrane tanks, of all vessels intended to carry liquefied natural gas (LNG) or liquefied petroleum gas (LPG) cargo are to meet the requirements of Class A.

3.3 Surface Vessels – Class B Criteria

Inspection of full penetration welds for surface vessels under 150 m (500 ft), and for welds located outside midship 0.6*L*, regardless of the size of the vessels, is to meet the requirements of Class B, provided that Class A has not been specified in accordance with the special conditions noted in the Class A Criteria above.

3.5 Other Marine and Offshore Structures

Inspection of full penetration welds is to be in accordance with Class A, unless otherwise specified in the applicable Rules (e.g., ABS *Rules for Building and Classing Mobile Offshore Drilling Units*).

5 Evaluation from Visual Inspection (VT), Magnetic Inspection (MT) and Liquid Penetrant Inspection (PT) *(1 September 2011)*

5.1 Shape

Flaw indications are to be classified as either linear or rounded.

i) *Linear flaw indications* are classified as having a length equal to or greater than 3 times (3x) the width.

ii) *Rounded flaw indications* are classified as having a circular or elliptical shape and the length of the ellipse is less than 3 times (3x) the width.

5.3 Flaw Indications (MT)

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

5.3.1

Relevant indications are produced by leakage fields which are the result of discontinuities. Relevant indications require evaluation with regard to the acceptance standards stated below.

5.3.2

Non-relevant 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.

5.3.3

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.

5.5 Evaluation from Surface Inspection

Evaluation from surface inspection is to be made in accordance with the following acceptance criteria.

5.5.1 Weld Appearance, Size and Shape

Welds are to meet the following requirements:

i) Welds are to be regular and uniform with a minimum amount of reinforcement.

ii) Welds are to be free from excessive overlap, excessive convexity, and undersize weld or underfill.

iii) Thorough fusion shall exist between adjacent layers of weld metal and between weld metal and base metal.

iv) All craters shall be filled to their specified weld size.

v) For welds exhibiting undercut, refer to 8/5.5.5 below. At the discretion of the Surveyor, undercut considered non-conforming is subject to be inspected further by other nondestructive test methods such as magnetic particle method, liquid penetrant method, radiographic method, or ultrasonic method.

vi) Arc strikes outside the weld groove are to be dressed and removed.

5.5.2 Cracks

Welds are to be free of any type of crack.

5.5.3 Incomplete Fusion

Welds are to be free of any lack of fusion between weld metal and base metal.

5.5.4 Porosity

i) Complete joint penetration (CJP) groove welds in butt joints transverse to the members subject to tensile stress are not to have piping porosity. For all other complete joint penetration (CJP) groove welds and full penetration fillet welds, the frequency of piping porosity is not to exceed one in each 100 mm (4 in.) of length and the maximum diameter is not to exceed 2.5 mm (0.1 in.).

ii) For fillet welds connecting stiffeners to web and partial penetration fillet welds, the sum of the piping porosity 1 mm ($^1/_{24}$ in.) or greater in diameter is not to exceed 10 mm ($^3/_8$ in.) in any linear 25 mm (1 in.) of weld and is not to exceed 19 mm ($^3/_4$ in.) in any 300 mm (12 in.) length of weld. The maximum diameter of the piping porosity is not to exceed 2.5 mm ($^3/_{32}$ in.).

5.5.5 Undercut

Undercut refers to a groove melted in the base metal adjacent to a weld toe at the face or root of the weld. In addition to visual inspection requirement on undercut in 8/5.5.1 above, undercut revealed from VT, MT or PT have the following acceptance criteria for butt welds and fillet welds:

i) In primary members, undercut is to be no more than 0.25 mm (0.01 in.) deep when the weld is transverse to tensile stress under any design loading condition.

ii) For all other cases:

- Undercut depth up to 0.5 mm ($^{1}/_{64}$ in.) is acceptable, whatever the length
- Undercut depth up to 0.8 mm ($^{1}/_{32}$ in.) with a maximum continuous length of 90 mm (3½ in.) is acceptable. Adjacent undercuts separated by a distance shorter than the shortest undercut should be regarded as a single continuous undercut.

iii) Assessment of depth is to be done by visual and mechanical means, and assessment of depth using magnetic particle or liquid penetrant method is not acceptable

7 Evaluation from Radiographic Inspection

Evaluation from radiographic inspection is to be made in accordance with the following acceptance criteria.

7.1 Cracks

Welds in which radiographs exhibit any type of crack are to be considered unacceptable.

7.3 Incomplete Fusion or Incomplete Penetration

Lack of fusion in any portion of the weld deposit or between the weld deposit and the adjacent base metal is to be treated as incomplete fusion or incomplete penetration.

7.3.1 Class A and Class B

Radiographs of welds exhibiting indications of incomplete fusion or incomplete penetration greater than those shown in the respective curves of Section 8, Figure 1 for single and total accumulated length are non-conforming.

7.5 Slag

Non-metallic solid material entrapped in the weld deposit or between the weld deposit and the adjacent base metal is to be treated as slag.

When determining the total accumulated length of slag for each class, acceptable incomplete fusion or incomplete penetration indications are to be treated as slag.

7.5.1 Incomplete Fusion

Incomplete penetration and slag indications less than 3 mm ($^{1}/_{8}$ in.) in length may be evaluated as slag or porosity, whichever is less restrictive.

7.5.2 Class A

Radiographs of welds exhibiting indications of slag greater than those shown in the respective curves of Section 8, Figure 2 for single or total accumulated length are non-conforming.

7.5.3 Class B

Radiographs of welds exhibiting indications of slag greater than those shown in the respective curves of Section 8, Figure 3 for single or total accumulated length are non-conforming.

7.7 Porosity

Gas pockets, circular voids, and well-dispersed tungsten inclusions are to be treated as porosity.

7.7.1 Class A and Class B

Radiographs of welds exhibiting porosity concentrations greater than those shown in the charts of Section 8, Figures 4 through 10, for any 150 mm (6 in.) weld length, for material ranging from 6.2 mm ($^{1}/_{4}$ in.) to 50 mm (2 in.) in thickness, are non-conforming.

7.7.2 Material Thickness Greater than 50 mm (2 in.)

Radiographs of welds exhibiting porosity distributions and concentrations that differ significantly from those shown in Section 8, Figure 10 are to have the actual number and size of the pores recorded and the total area of porosity calculated.

The calculated area is not to exceed 2.3t mm^2 (0.09t in^2) in any 150 mm (6 in.) length of weld where t is the thickness of the material in mm (in.).

7.7.3 Isolated Pores

The maximum size of a single isolated pore may be 0.25t or 4.8 mm ($^3/_{16}$ in.), whichever is less, where t is the thickness of the material, provided that there is only one such pore in any 150 mm (6 in.) weld length and the total area of porosity is in accordance with 8/7.7.1 above.

7.7.4 Fine Porosity

Porosity smaller than 0.4 mm ($^1/_{64}$ in.) in diameter may be disregarded.

7.7.5 Linear Porosity or Aligned Round Indication *(1 September 2011)*

Four or more indications in a line, where each is separated from the adjacent indication by less than 1.6 mm ($^1/_{16}$ in.) or D, whichever is greater, where D is the major diameter of the larger of the adjacent indications. This linear porosity or aligned round indications are to be judged as slag.

7.9 Multiple Indications

Radiographs of welds exhibiting indications of porosity and slag (including acceptable incomplete fusion or incomplete penetration) are to be judged as follows:

7.9.1

If the radiograph approximates all the permissible slag, only 50% of the permissible porosity is to be allowed.

7.9.2

If the radiograph approximates all the permissible porosity, only 50% of the total accumulated permissible slag is to be allowed.

7.9.3

The percent of permissible slag plus the percent of permissible porosity is not to exceed 150%.

7.11 Undercut *(1 September 2011)*

Acceptance criteria for undercut indications are the same as the acceptance criteria from magnetic inspection and liquid penetrant inspection (8/5.5.5 above). Assessment of depth is to be done by visual and mechanical means. Assessment of depth using radiography is not acceptable.

9 Evaluation from Ultrasonic Inspection

Evaluation from ultrasonic inspection is to be made in accordance with the following acceptance criteria.

9.1 Class A

9.1.1 Indications Greater than the ARL *(1 September 2011)*

i) Flaw indications with amplitude responses exceeding the ARL (as established in 3/3.9) and having a length greater than 12.5 mm ($^1/_2$ in.) are non-conforming.

ii) Flaw indications less than 4.8 mm ($^3/_{16}$ in.) in length may be disregarded.

iii) Flaw indications 4.8 mm ($^3/_{16}$ in.) to 12.5 mm ($^1/_2$ in.) in length are to be evaluated in accordance with 8/9.1.2 below.

9.1.2 Indications Greater than the DRL *(1 September 2011)*

i) Flaw indications with amplitude responses exceeding the DRL (as established in 3/3.9) are non-conforming if the signals are indicative of discontinuities greater in length than those shown in the respective curves of Section 8, Figure 11 for single or total accumulated length.

ii) Indications less than 4.8 mm ($^3/_{16}$ in.) in length may be disregarded.

9.1.3 Indications Less than the DRL

i) Ultrasonic signals which are less than the DRL are to be disregarded.

9.3 Class B

9.3.1 Indications Greater than the ARL *(1 September 2011)*

i) Flaw indications with amplitude responses exceeding the ARL (as established in 3/3.9) and having a length greater than 12.5 mm ($^1/_2$ in) are non-conforming.

ii) Flaw indications less than 4.8 mm ($^3/_{16}$ in.) in length may be disregarded.

iii) Flaw indications 4.8 mm ($^3/_{16}$ in.) to 12.5 mm ($^1/_2$ in.) in length are to be evaluated in accordance with 8/9.3.2 below.

9.3.2 Indications Greater than the DRL *(1 September 2011)*

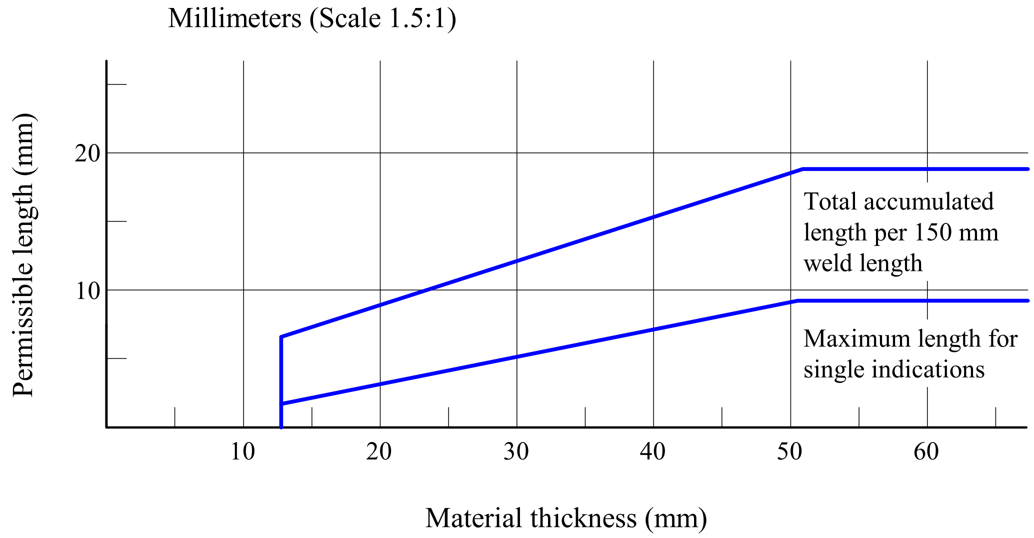
i) Flaw indications with amplitude responses exceeding the DRL (as established in 3/3.9) are non-conforming if the signals are indicative of discontinuities greater in length than those shown in the respective curves of Section 8, Figure 12 for single or total accumulated length

ii) Indications less than 4.8 mm ($^3/_{16}$ in.) in length may be disregarded.

9.3.3 Indications Less than the DRL

i) Ultrasonic signals which are less than the DRL are to be disregarded.

FIGURE 1
Class A and Class B Incomplete Fusion and Incomplete Penetration – Acceptable Length



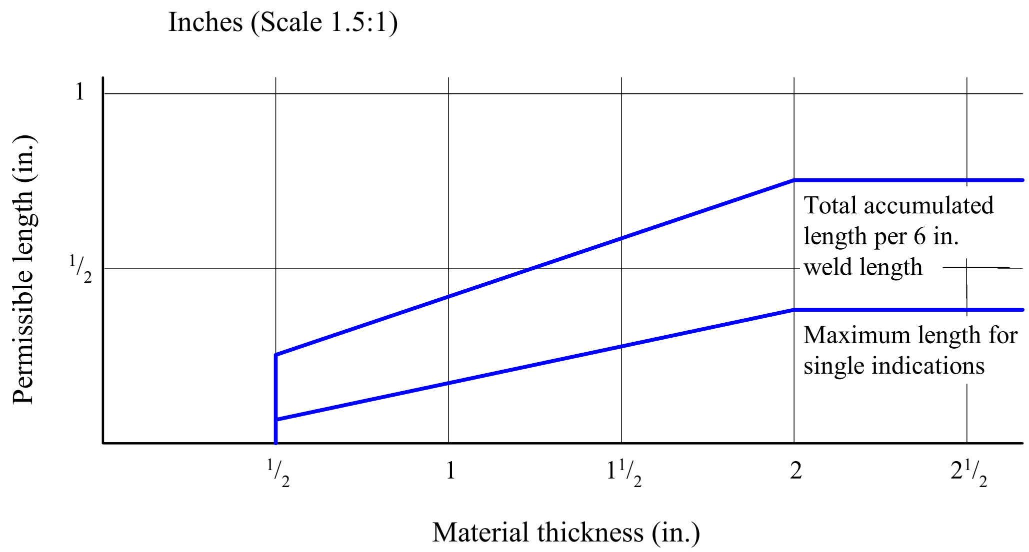
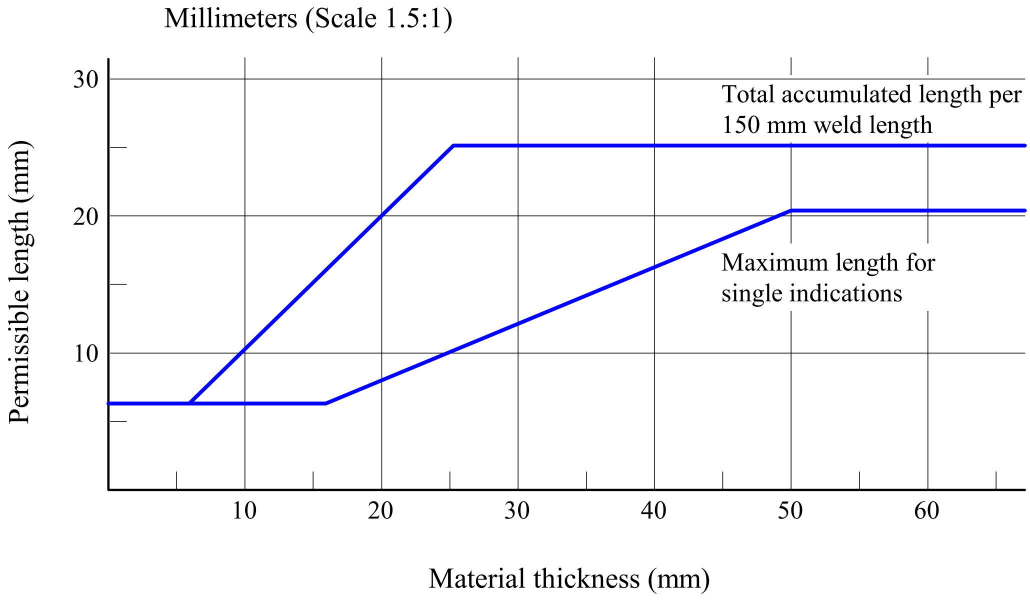


FIGURE 2
Class A Slag – Acceptable Length

Total accumulated slag is to include incomplete fusion and incomplete penetration when allowed by Section 8, Figure 1 above.



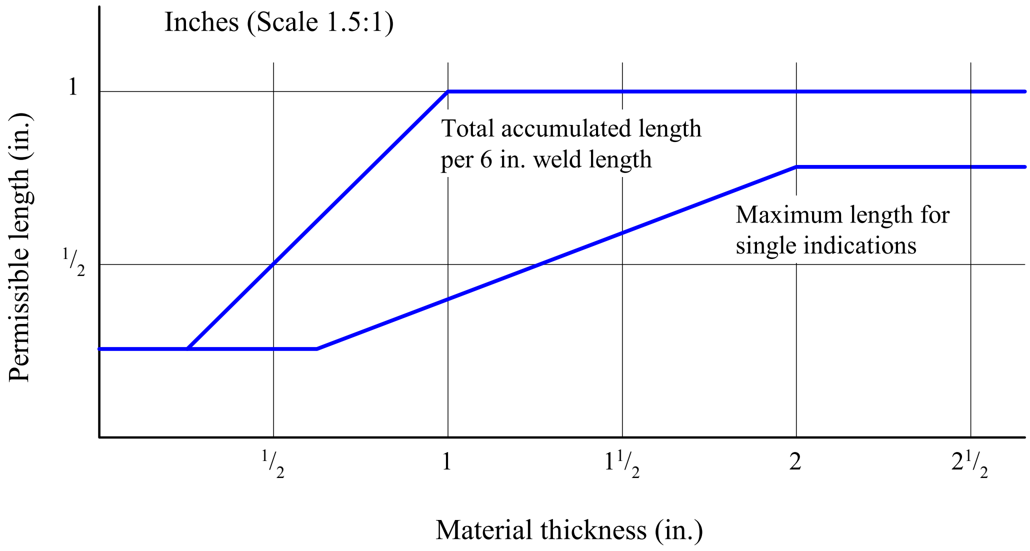


FIGURE 3
Class B Slag – Acceptable Length

Total accumulated slag is to include incomplete fusion and incomplete penetration when allowed by Section 8, Figure 1 above.

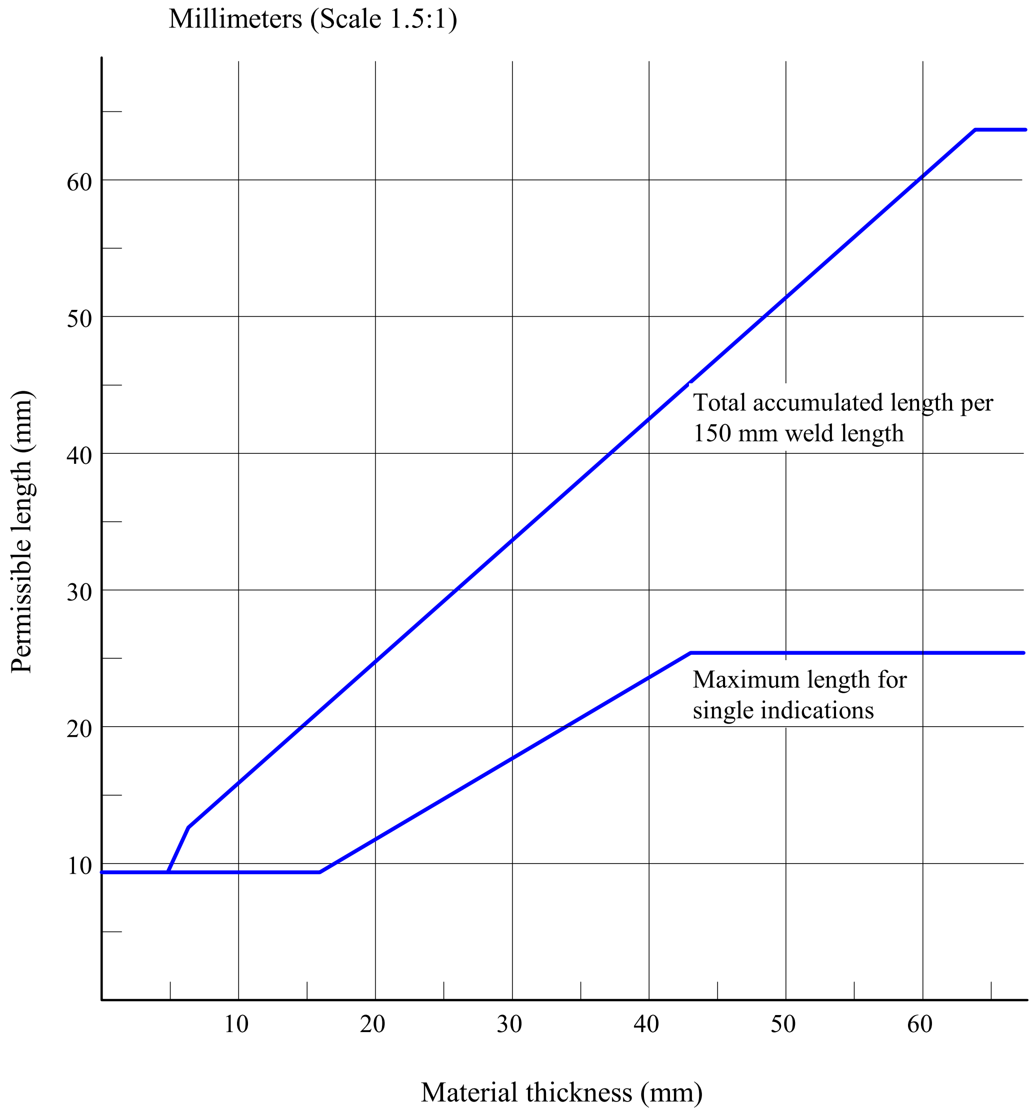


FIGURE 3 (continued)
Class B Slag – Acceptable Length

Total accumulated slag is to include incomplete fusion and incomplete penetration when allowed by Section 8, Figure 1 above.

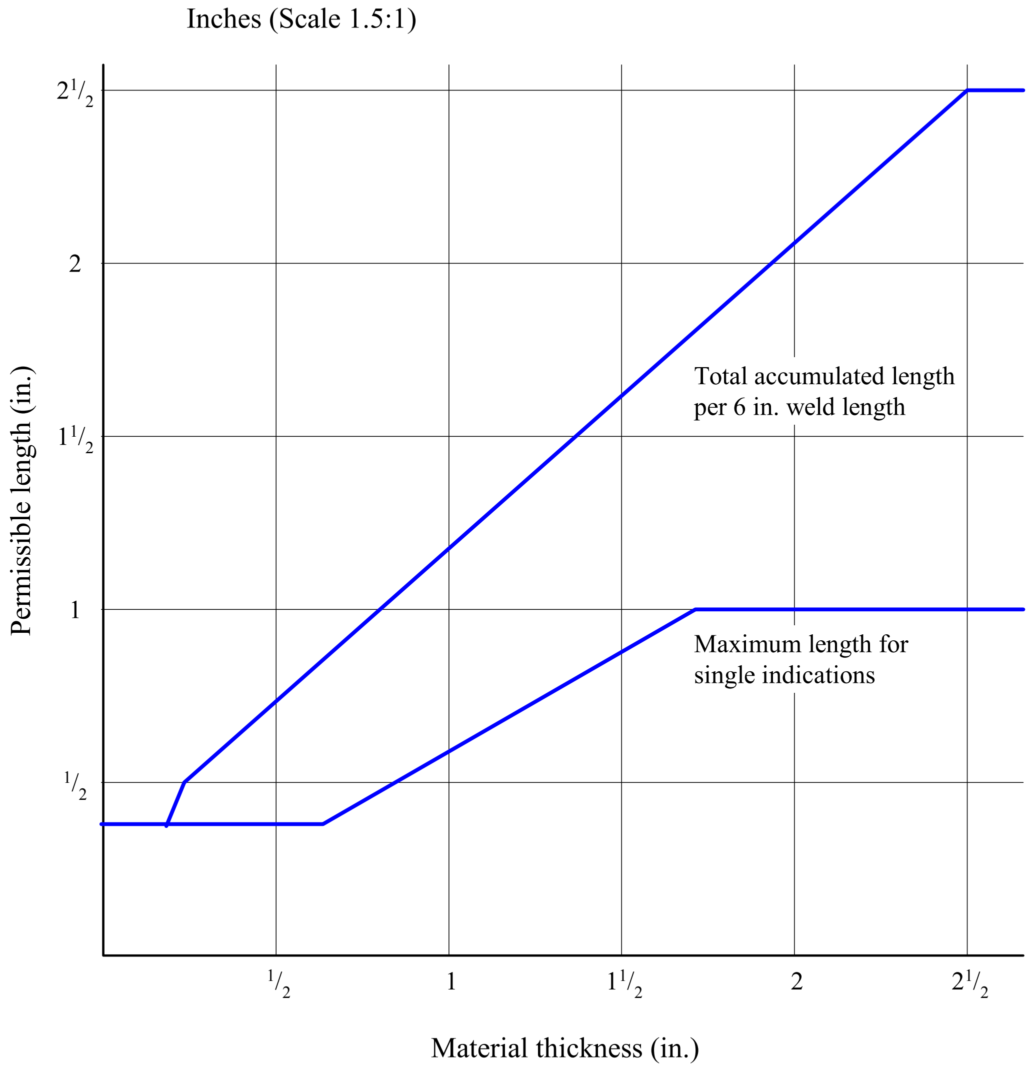
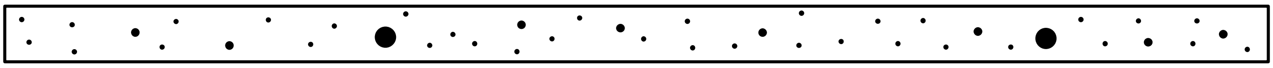


FIGURE 4
Class A and Class B Porosity Chart for 6.2 mm (0.25 in.) Thick Material
(1 September 2011)

Total porosity area permitted 15 mm^2 per 150 mm (0.023 in.^{2} per 6 in.) weld length

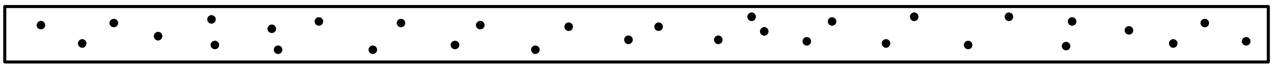
Pore type	Pore diameter	Allowable pores
Assorted	2.16 mm (0.085 in.)	2
	0.75 mm (0.03 in.)	8
	0.38 mm (0.015 in.)	34
Large	2.16 mm (0.085 in.)	4
Medium	0.75 mm (0.03 in.)	32
Fine	0.38 mm (0.015 in.)	130

Assorted



Large

Medium



Fine

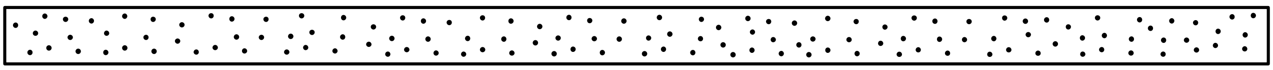
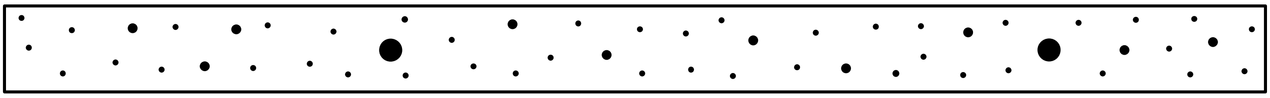


FIGURE 5
Class A and Class B Porosity Chart for 9.5 mm (0.375 in.) Thick Material
(1 September 2011)

Total porosity area permitted 22 mm^2 per 150 mm (0.034 in.^{2} per 6 in.) weld length

Pore type	Pore diameter	Allowable pores
Assorted	2.36 mm (0.093 in.)	2
	0.89 mm (0.035 in.)	10
	0.46 mm (0.018 in.)	42
Large	2.36 mm (0.093 in.)	5
Medium	0.89 mm (0.035 in.)	35
Fine	0.46 mm (0.018 in.)	133

Assorted



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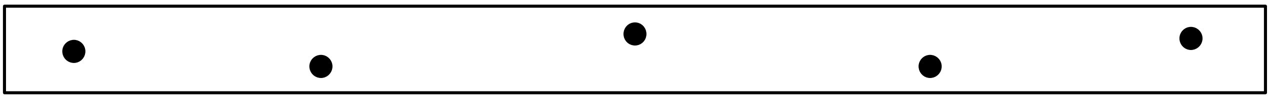

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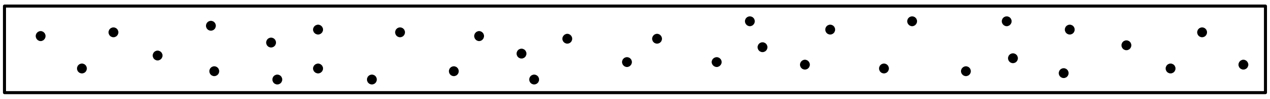

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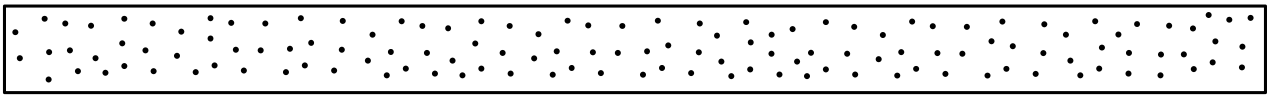
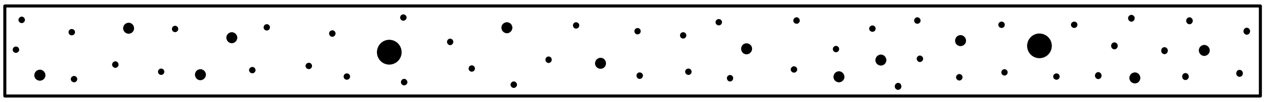


FIGURE 6
Class A and Class B Porosity Chart for 12.5 mm (0.5 in.) Thick Material

Total porosity area permitted 29 mm^2 per 150 mm (0.045 in.^{2} per 6 in.) weld length

Pore Type	Pore Diameter	Allowable pores
Assorted	2.54 mm (0.10 in.)	2
	1.02 mm (0.04 in.)	12
	0.508 mm (0.02 in.)	45
Large	2.54 mm (0.10 in.)	6
Medium	1.02 mm (0.04 in.)	36
Fine	0.508 mm (0.02 in.)	143

Assorted



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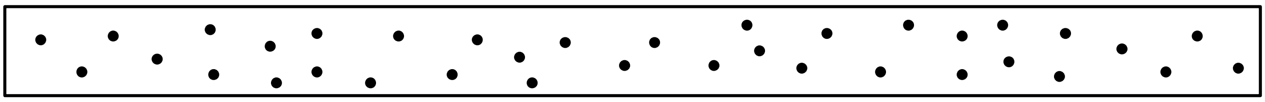
Medium



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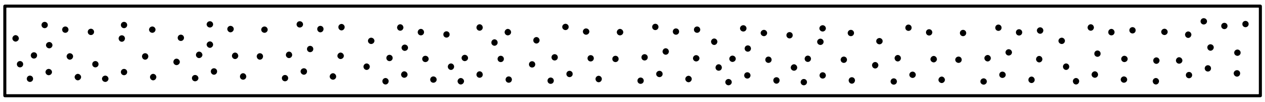
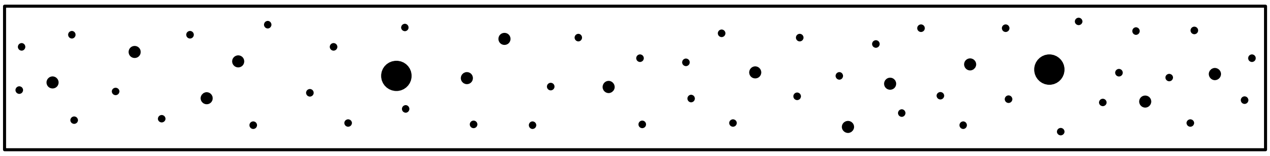


FIGURE 7
Class A and Class B Porosity Chart for 19.0 mm (0.75 in.) Thick Material

Total porosity area permitted 43.2 mm^2 per 150 mm (0.067 in.^{2} per 6 in.) weld length

Pore Type	Pore Diameter	Allowable pores
Assorted	3.17 mm (0.125 in.)	2
	1.14 mm (0.045 in.)	13
	0.635 mm (0.025 in.)	44
Large	3.17 mm (0.125 in.)	6
Medium	1.14 mm (0.045 in.)	42
Fine	0.635 mm (0.025 in.)	137

Assorted



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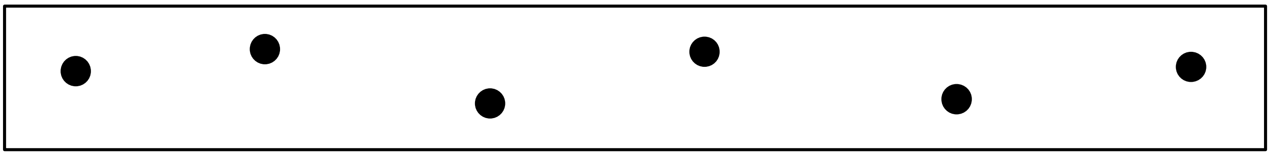

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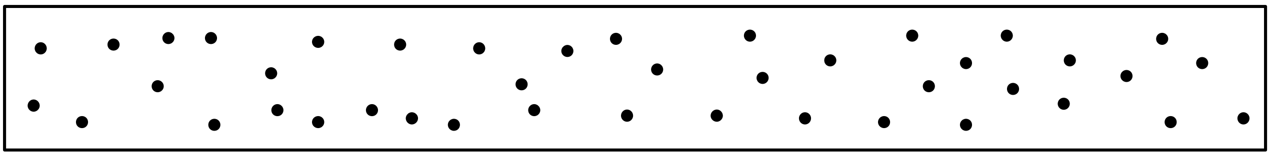

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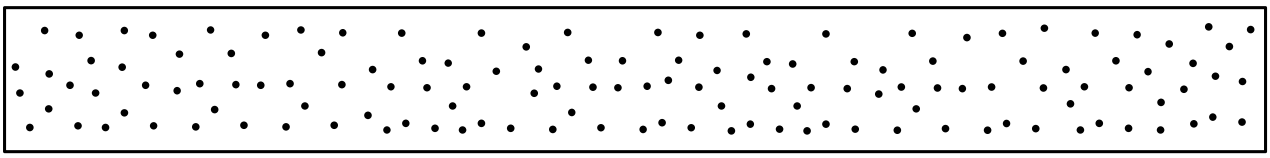
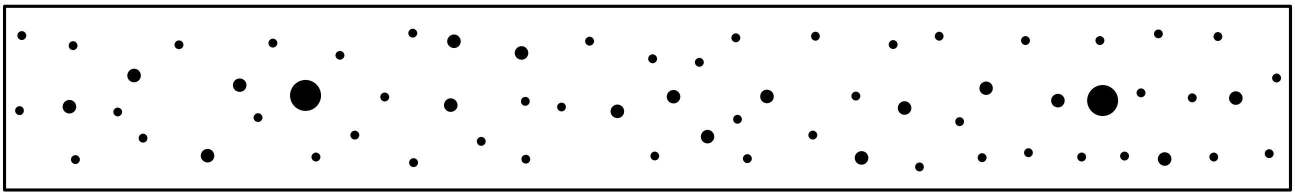


FIGURE 8
Class A and Class B Porosity Chart for 25 mm (1.0 in.) Thick Material

Total porosity area permitted 58.1 mm^2 per 150 mm (0.09 in.^{2} per 6 in.) weld length

Pore Type	Pore Diameter	Allowable pores
Assorted	3.17 mm (0.125 in.)	2
	1.27 mm (0.05 in.)	17
	0.762 mm (0.03 in.)	45
Large	3.17 mm (0.125 in.)	7
Medium	1.27 mm (0.05 in.)	46
Fine	0.762 mm (0.03 in.)	127

Assorted



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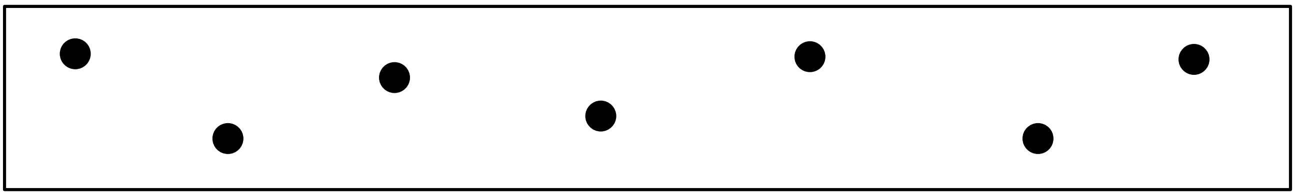

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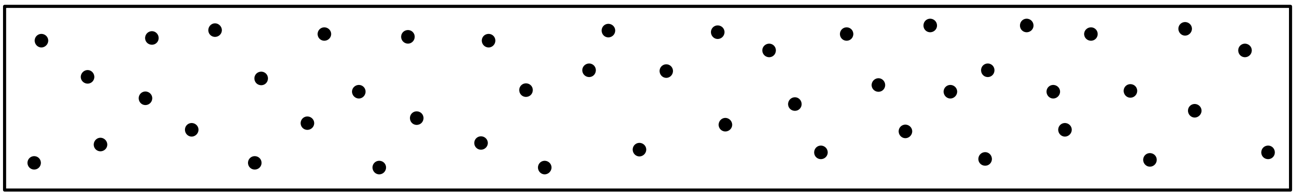

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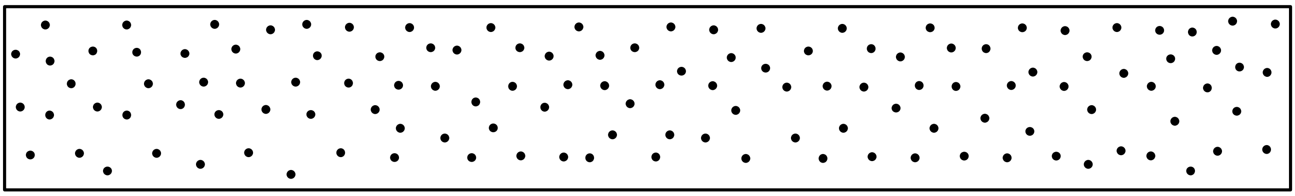
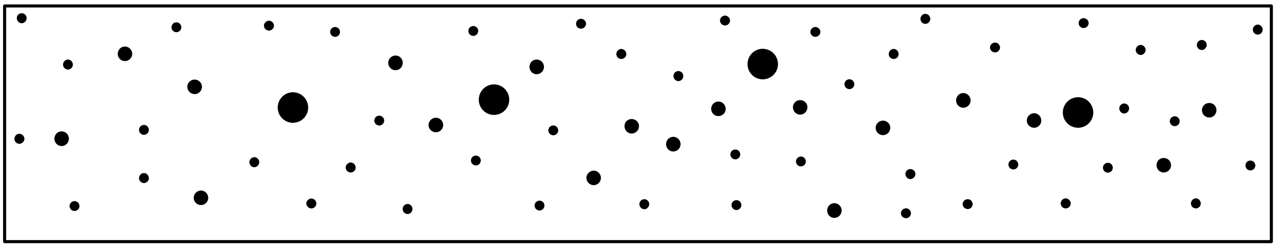


FIGURE 9
Class A and Class B Porosity Chart for 38.0 mm (1.5 in.) Thick Material

Total porosity area permitted 87.1 mm^2 per 150 mm (0.135 in.^{2} per 6 in.) weld length

Pore Type	Pore Diameter	Allowable pores
Assorted	3.17 mm (0.125 in.)	4
	1.4 mm (0.055 in.)	18
	0.89 mm (0.035 in.)	45
Large	3.17 mm (0.125 in.)	11
Medium	1.4 mm (0.055 in.)	57
Fine	0.89 mm (0.035 in.)	140

Assorted



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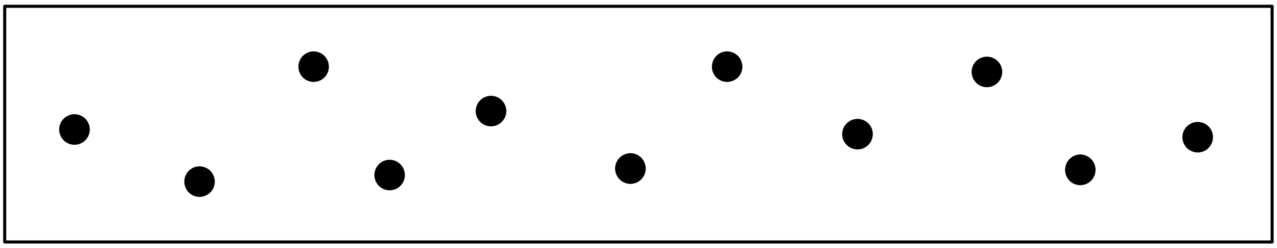

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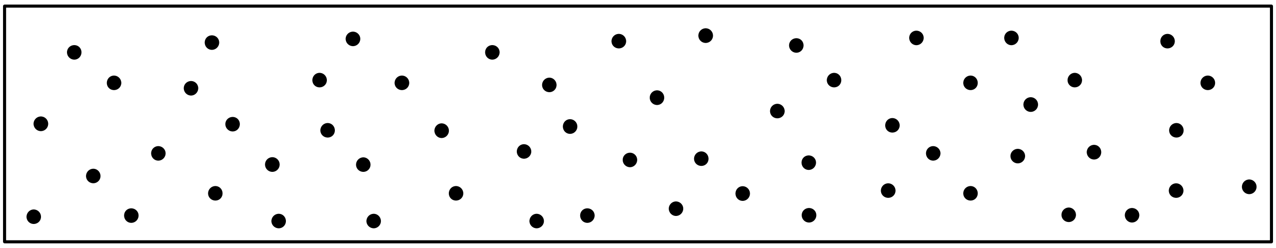

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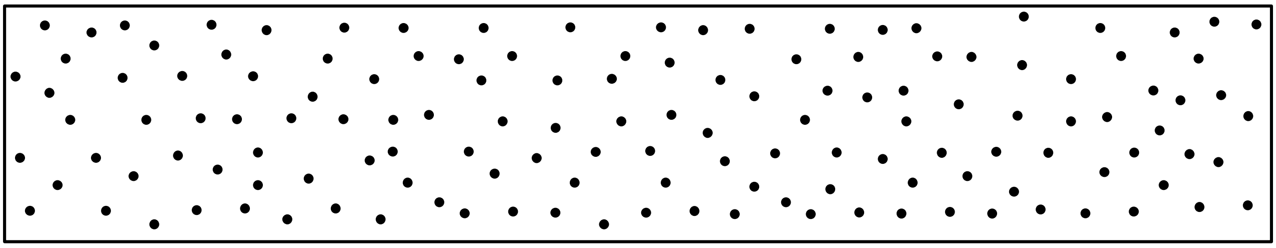
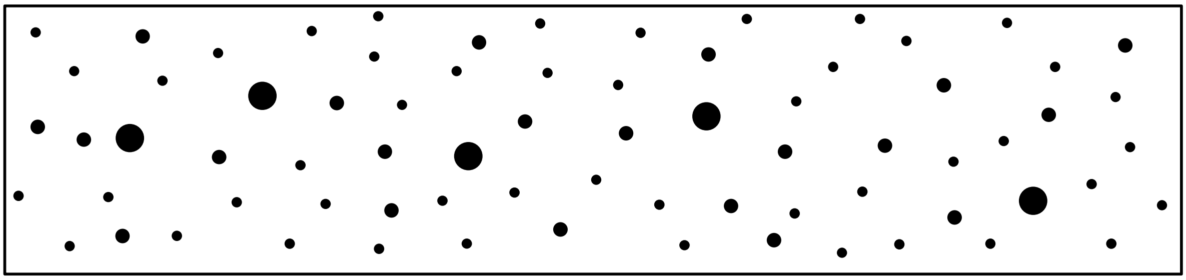


FIGURE 10
Class A and Class B Porosity Chart for 50 mm (2.0 in.) Thick Material

Total porosity area permitted 116 mm^2 per 150 mm (0.135 in.^{2} per 6 in.) weld length

Pore Type	Pore Diameter	Allowable pores
Assorted	3.17 mm (0.125 in.)	5
	1.52 mm (0.06 in.)	21
	1.02 mm (0.04 in.)	47
Large	3.17 mm (0.125 in.)	15
Medium	1.52 mm (0.06 in.)	64
Fine	1.02 mm (0.04 in.)	143

Assorted



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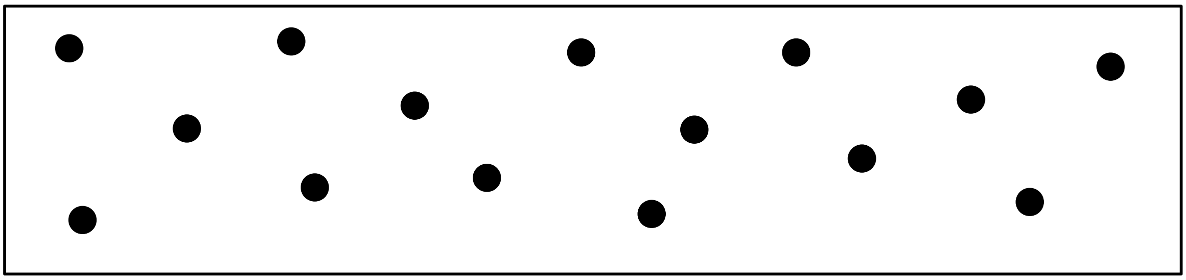
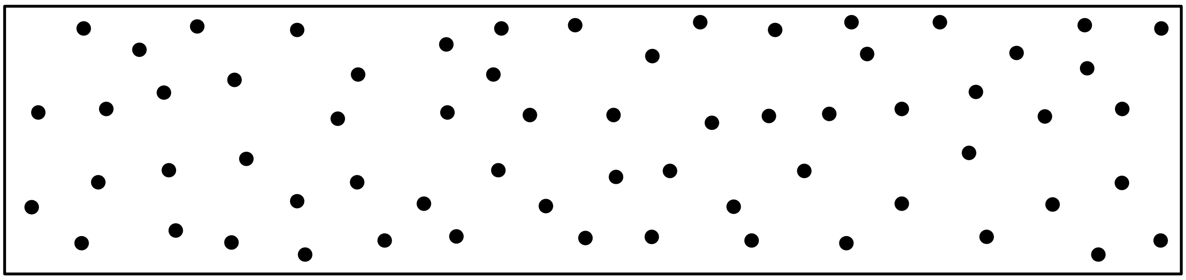


Medium



Fine

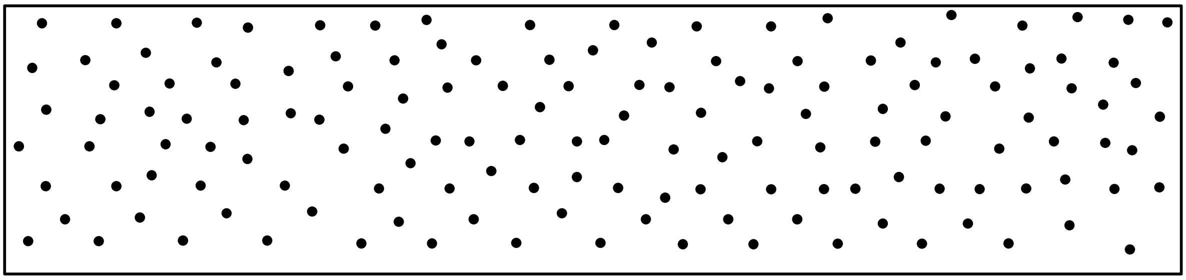
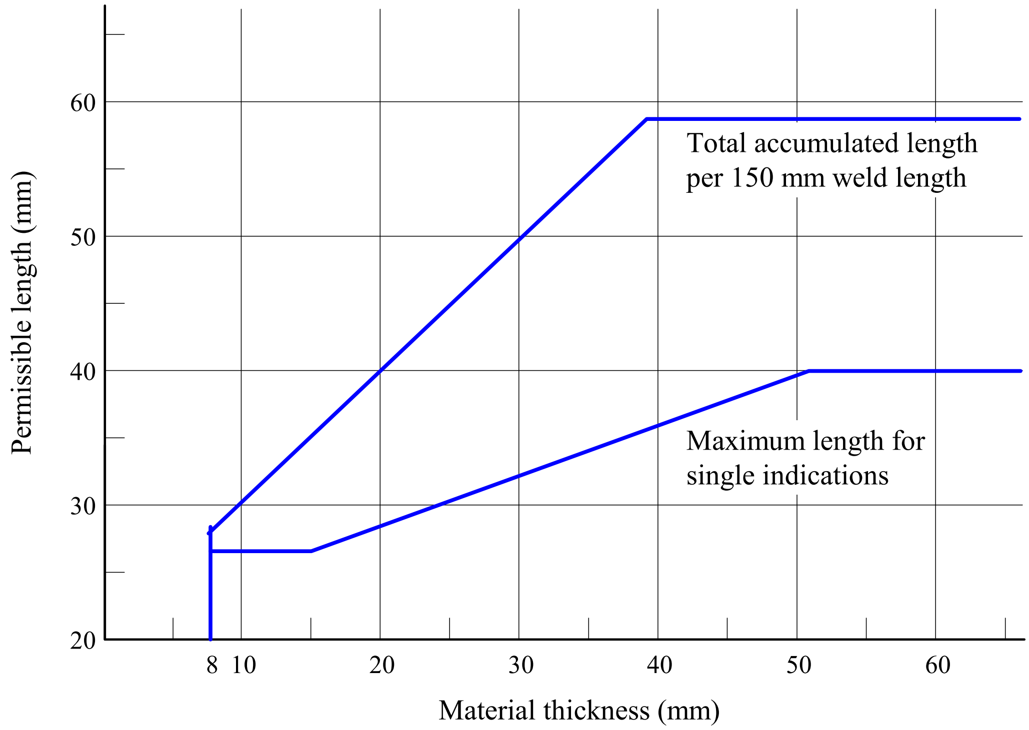


FIGURE 11
Class A – Maximum Acceptable Lengths for Ultrasonic Flaw Indications Greater than DRL

Millimeters (Scale 1.5:1)



Inches (Scale 1.5:1)

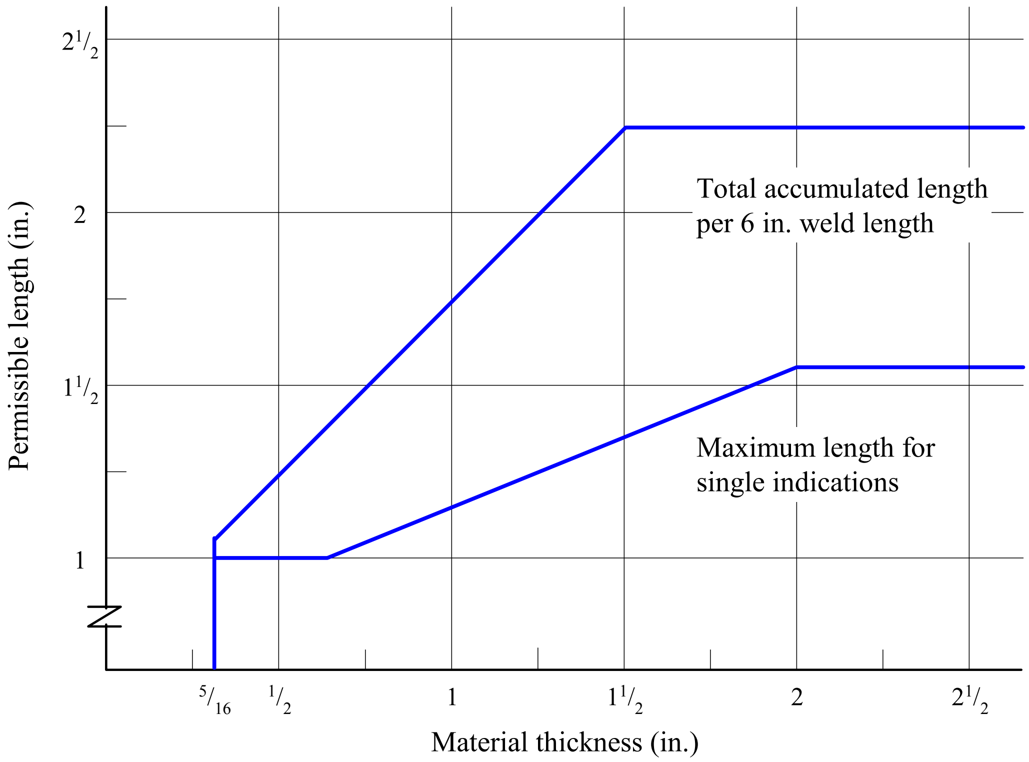


FIGURE 12
Class B – Maximum Acceptable Lengths for Ultrasonic Flaw Indications Greater than DRL

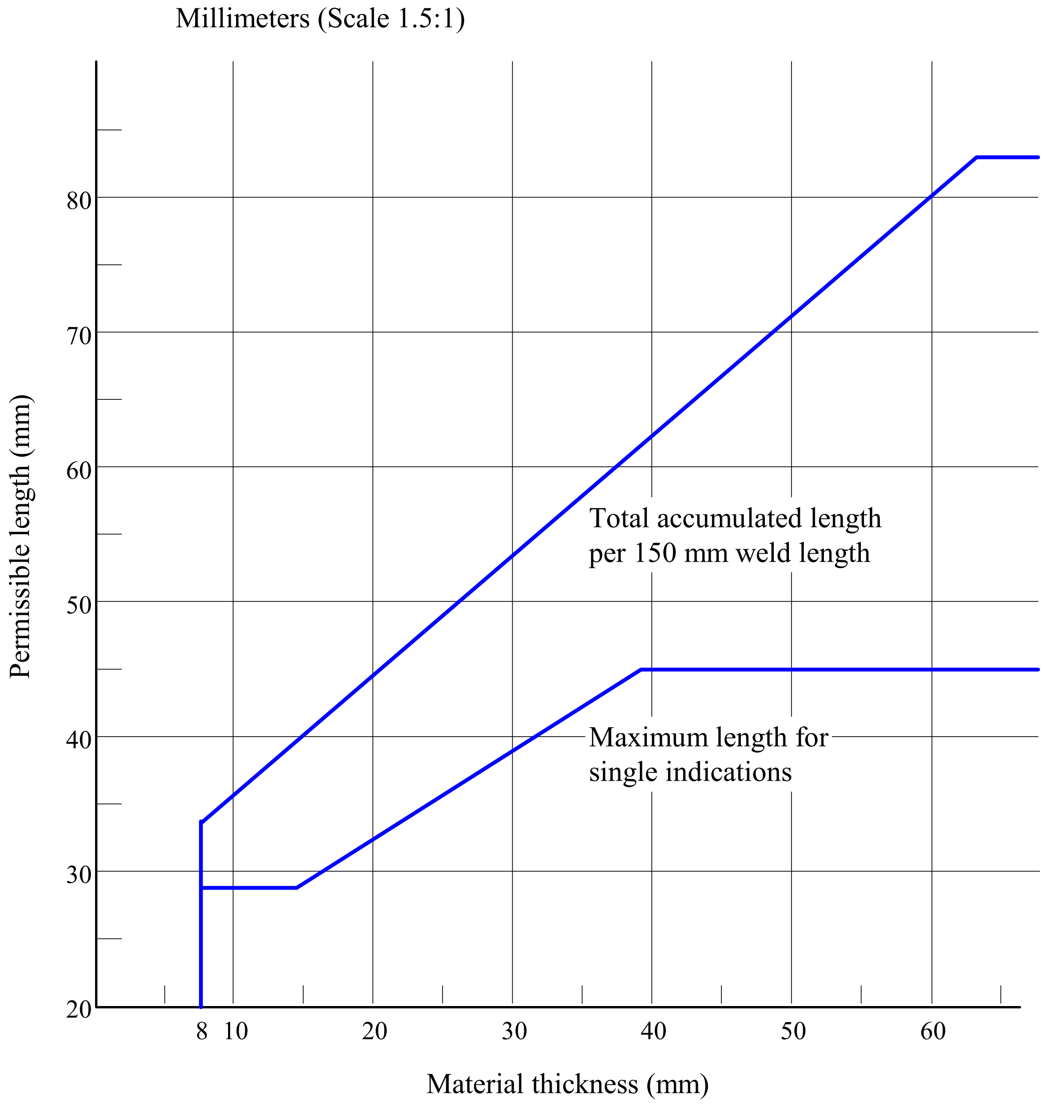
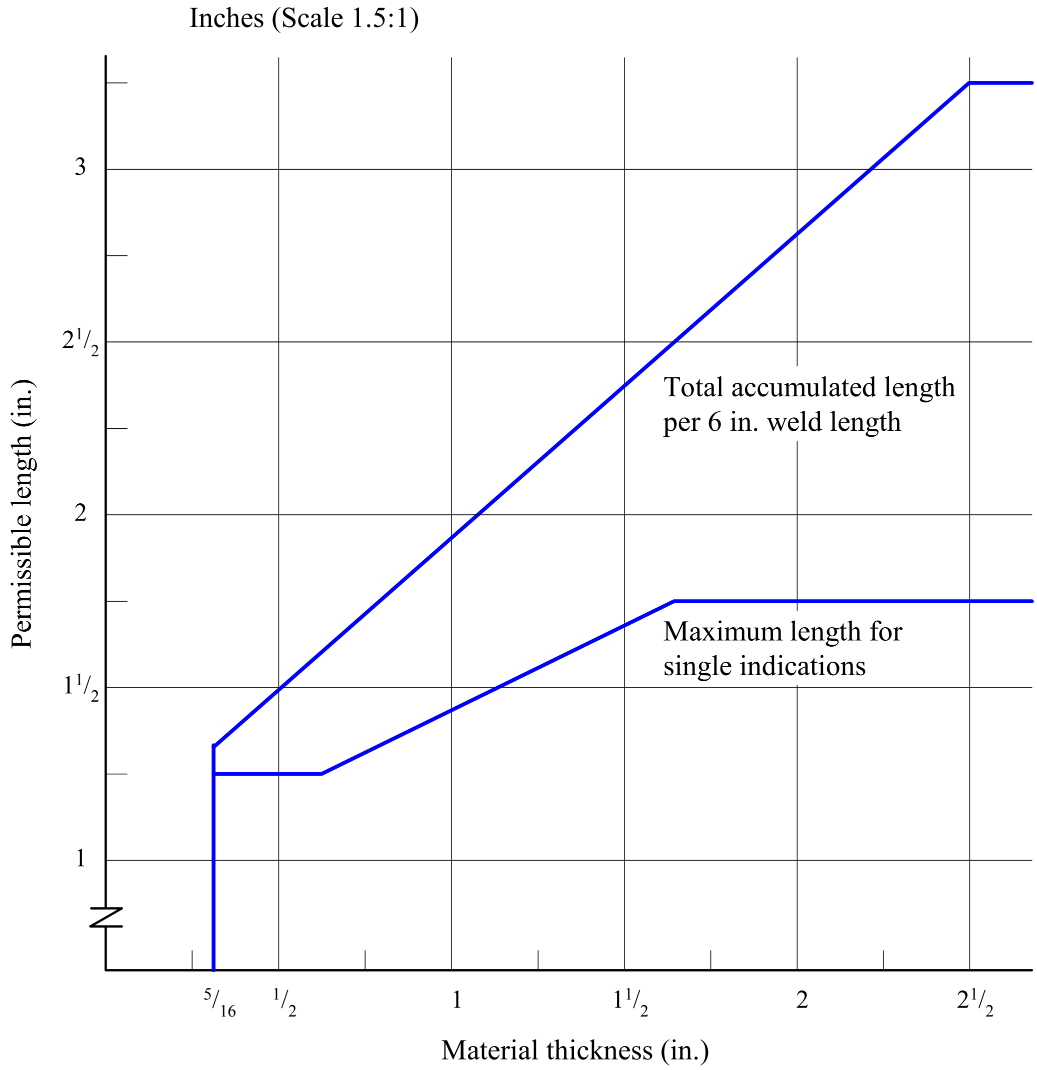


FIGURE 12 (continued)
Class B – Maximum Acceptable Lengths for Ultrasonic Flaw Indications Greater than DRL



APPENDIX 1 **Guidance for Radiographic (RT) and Ultrasonic (UT) Inspection of Hull Welds**

1 Purpose of ABS *Guide for Nondestructive Inspection of Hull Welds* *(1 September 2011)*

The purpose of this Guide is to provide means to ascertain that the internal soundness of full penetration butt welds in ship hull and other marine and offshore structures are of generally satisfactory quality. For other weld joints, see Appendix 2, "Guidance for Ultrasonic Inspection".

The use of RT or UT in accordance with this Guide provides a measure of general shipyard quality control. Acceptance levels for allowable sizes of discontinuities specified in this Guide are not based on fracture mechanics analyses since the variety and the complexity of factors involved could make such analyses of questionable validity. The acceptance/rejection levels of this Guide are based on experience and indicate the level of quality that should be reasonably expected with normal shipyard procedures and practices. The reject level at an isolated location does not necessarily indicate that the discontinuity represents a threat to the safety of the vessel. An abnormally high reject rate indicates that the fabrication and welding are not being adequately controlled, and may in some instances necessitate rejecting and repairing entire weldments. When relatively high levels of reject rate are being experienced, it is important to take immediate corrective action(s) to avoid the introduction of extensive areas of questionable weld quality. Corrective actions to improve the quality of welding may consist of re-examinations and/or re-qualifications of weld procedures and welder or in extreme cases, curtailment of welding until the causes producing the unsatisfactory level of overall weld quality are found and eliminated. Isolated rejectable indications within a vessel whose general weld quality is satisfactory are to be treated individually in accordance with Subsections 2/19 and 3/11 of this Guide.

3 Choice of Nondestructive Testing (NDT) Method *(1 September 2011)*

This Guide covers the use of RT and UT. However, the interpretation of indications using either of these methods is to be conducted in conjunction with visual examination of the corresponding welds. For example, a surface condition such as undercut may give an indication with both RT and UT, and therefore, might be misinterpreted as a rejectable internal indication based on length on a radiograph or on percentage of full screen height (FSH). With a visual examination (Subsection 1/1 and IACS Recommendation No. 47 "Shipbuilding and Repair Quality Standard" for maximum allowable size of undercuts), the indication caused by the undercut can be taken into account in interpretation of the indications obtained from RT or UT. An actual depth measurement of the undercut might change the acceptance/rejection status of the condition, depending on the code or other criteria used. The undercut, however, should be dealt with to the satisfaction of the Surveyor. For this and other reasons, a visual examination is essential prior to using NDT methods for detection of internal discontinuities. In addition, the person doing the interpretation, as well as all interested parties, should be thoroughly knowledgeable with the welding process and the joint design of the weld being evaluated.

RT and UT are used for detection of internal discontinuities, and in essence, they supplement and complement each other. Each method is suited for the detection of particular types and orientations of discontinuities.

RT is generally most effective in detecting non-planar (three-dimensional) discontinuities, such as porosity and slag, and is less effective for detecting planar (two-dimensional) discontinuities, such as laminations or cracks.

UT, on the other hand, is generally most effective for detecting planar discontinuities and is less effective for detecting non-planar discontinuities.

Either RT or UT can be chosen as the primary method of inspection. However, if a yard desires to use UT as the primary method, such testing is to be supplemented initially and by periodical checks with a reasonable amount of radiographic inspection to determine that adequate quality control is achieved as in Subsection 3/3 of this Guide. Although one method may not be directly relatable to the other, either one would indicate conditions of inadequate control of the welding process. Since either method is acceptable as an inspection method, the choice might be influenced the following considerations:

- Need for permanent record (available with AUT, not generally provided by manual UT)
- The type and orientation of discontinuities of concern
- Equipment availability and cost
- Yard experience with a particular method
- Accessibility for inspection (i.e., UT generally requires access to only one surface, whereas RT requires two)
- Personnel safety
- Portability

The Surveyor, at his discretion, may require a specific NDT method where he believes the method selected by the shipyard (UT or RT) is not appropriate for types and orientation of discontinuities of concern.

RT and UT methods are supplementary and complementary to each other in that each has different discontinuity detection characteristics and capabilities, and therefore, each has its corresponding criteria which must be used accordingly. Because of distinct differences in characteristics between the two methods, it is not reasonable to expect that a weld examined and found acceptable by one method will always be acceptable by the other method. Therefore, the results obtained with the particular method originally selected as the basis for approval governs unless gross defects considered detrimental to the integrity of the structure are discovered when using the other method. It should be emphasized that the primary purpose of the Rules requiring NDT of hull structural welds is to provide means to verify that butt welds are of generally satisfactory quality.

5 Extent and Location of RT or UT *(1 September 2011)*

For surface vessels, details of extent and location of inspection are included in this Guide. For other structures, such as Mobile or Fixed Offshore Structures, see the welding section of the appropriate Rules.

Because the specified extent of inspection represents only a small percentage of total weld length, the results of the inspection only provide a general indication of the weld quality level, and it is generally reasonable to assume that the uninspected areas may have roughly the same proportion of unacceptable levels of indications as is found in the inspected locations. Indications beyond acceptable levels reflect a level of workmanship lower than the expected quality, and do not indicate a relationship to structural integrity, in that, for the reason previously noted, the allowable discontinuity sizes were not determined by fracture mechanic analysis. The following considerations should also be taken into account:

i) Important welds in special application and other important structure which are inaccessible or very difficult to inspect in service are to be subjected to an increased level of nondestructive inspection during construction. This provision may be relaxed for automated welds for which quality assurance techniques indicate consistent satisfactory quality.

ii) Field erected welds are to be subjected to an increased level of nondestructive inspection.

iii) Welds which impose high residual stresses should be ultrasonically inspected to an extent that provides the Surveyor assurance of freedom from lamellar tearing after welding.

iv) Extent of inspection is at the discretion of the Surveyor depending on the type of structure, the material and welding procedures involved and the quality control procedures employed.

v) If the proportion of unacceptable weld quality becomes abnormally high, the frequency of inspection is to be increased.

vi) ABS does recognize and take into account Owner and designer specifications which are in excess of ABS requirements and may require 100% inspection of certain connections. When such additional inspection is conducted by RT or UT, unless approved otherwise, the following is applicable:

- *Full Penetration Butt Welds.* For locations where inspection is specified on the approval plan or required by the Surveyor, the acceptance standards of this Guide appropriate to the structure involved are applicable. For other locations where inspection was not required by ABS, the guidance of Appendix 4 is applicable.
- *Full Penetration Tee or Corner Welds.* The guidance of Appendix 2 is applicable.

APPENDIX 2 Guidance for Ultrasonic Inspection

1 Ultrasonic Inspection of Full Penetration Tee and Corner Welds

(1 September 2011) This Guide contains requirements for ultrasonic inspection of full penetration welds for ships and other marine and offshore structures. Some approved plans for offshore mobile and fixed structures may specially require ultrasonic inspection in way of critical full penetration tee and corner connections to verify weld soundness. In other cases, ultrasonic inspection of these connections may be required in the course of a periodic or damage survey. This Appendix is intended to provide guidance for such inspections.

1.1 General

Except for scanning methods and acceptance standards, the provisions of this Guide relative to ultrasonic inspection are applicable.

1.3 Inspection of Plate Prior to Welding *(1 September 2011)*

It is required to inspect plates in way of full penetration tee and corner welds prior to welding to avoid plate discontinuities in the joint area, which could interfere with the final ultrasonic inspection. Such plate discontinuities found during this examination shall be recorded and evaluated on a case-by-case basis.

1.5 Ultrasonic Testing Procedure After Welding *(1 September 2011)*

The inspection procedure for verification of weld soundness is to be as follows:

i) Shear wave technique and/or compression wave (dual-element probe is recommended for lamination detection) technique is to be employed.

ii) Surfaces A and B are to be scanned as indicated in Appendix 2, Figure 1 to an extent which would provide the inspection of the complete weld area.

iii) At the discretion of the Surveyor, Surface C or corner welds may be required to be scanned if accessible as indicated in Appendix 2, Figure 1 to an extent which would provide detection of lamellar tearing.

1.7 Plate Discontinuities Detected After Welding

In the course of weld inspection, indications may be obtained from plate discontinuities either pre-existing or developed as a result of welding. In some cases, the latter may be lamellar tearing caused by high residual weld stresses. Indications which are attributable to discontinuities in plates in way of the weld may be considered acceptable if they are in accordance with the Class B standards of this Guide. Pre-existing indications observed in welded plate should be disregarded where there is no indication of propagation. Consideration as to the need, if any, for corrective measures should be based on the acceptability of the indications obtained, the functional requirements of the joint, as well as the practical level of workmanship quality which can be obtained.

1.9 Acceptance Criteria

The Class A acceptance standard specified in this Guide is to apply, except for the root area of those welds for which design drawings provide less than full penetration welds. Indications of lamellar tearing beyond that permitted in A2/1.7 above are to be treated on a case-by-case basis, taking into account the applications and circumstances involved.

1.11 Alternate Acceptance Criteria

Acceptance criteria submitted by the fabricator which are satisfactory to the designer/Owner may also be applied.

1.13 Applicability of Acceptance Criteria

The acceptance criteria of A2/1.9 or A2/1.11 above are only applicable to the specific locations indicated in the approved plans or as required by the Surveyor. Acceptance criteria for locations other than those required by ABS are considered as agreed upon between fabricator and Owner.

3 Ultrasonic Inspection of Welds in Thin Plate Less Than 8 mm *(1 September 2011)*

Acceptance requirements for the ultrasonic inspection of carbon and low alloy steels in hull structures from this Guide are intended for full penetration welds only. They are not intended to cover material less than 8 mm (0.3125 in.). In case of inspection of thin steel plate in thickness less than 8 mm (0.3125 in.), modified techniques described here are to be considered.

3.1 Selection of Probe Dimensions

A statement made in 3/3.7.3 of this Guide indicates the probe element size should be selected to be less than or equal to the wall thickness of the plate in which the weld inspected. This is of particular advantage in very thin wall sections (≤ 8 mm).

The primary reason for selection of a small probe used on thin wall plates relates to near zone considerations. The approximate near zone distance from the element face is given as following:

$N = D^2/4\lambda$ for circular elements

where

N = near zone

D = diameter of the element

λ = wavelength of the sound in the test medium

For a 5 MHz with 12.5 mm (0.5 in.) diameter element using the transverse (shear wave) velocity of steel (3240 m/s), N is approximately 60 mm from the probe element. When the probe element diameter is reduced to 6.4 mm (0.25 in.) the near zone reduces to about 16 mm in steel. When imaged with a fixed path length in a refracting wedge at 70° refracted angle on a 6.4 mm (0.25 in.) thick plate, the 12.5 mm diameter probe is seen to have the near zone in the third leg of the skip path while the 6.4 mm diameter probe has the near zone in the first leg of the skip path (well before the far side of the plate is reached). Appendix 2, Figure 2 illustrates the computed near zones for the two probe diameters mounted on typical wedges manufactured.

From Appendix 2, Figure 3, it becomes immediately obvious that a second advantage exists in the ability of the smaller dimensioned probe to approach the weld cap closer. The closest approach of the larger wedge to the weld cap prevents centerline of the beam approaching and being incident on the weld bevel at the root. The larger dimensioned probe can approach the weld bevel at the root by pulling the probe back till the beam is in the fourth leg of the skip path. In contrast, the smaller dimensioned probe can be positioned for the beam to reach the root in the first leg of the skip path as shown in Appendix 2, Figure 3.

Further consideration for selection of a small probe used on thin wall plates comes from the ability of the beam to resolve flaws and discriminate from geometric conditions. Beam pressure modeling software indicates, as shown in Appendix 2, Figures 4 and 5, that the actual dimensions of the beam are significantly greater for the larger probe than the smaller probe in the practical working range (i.e., up to the end of the first full skip). Appendix 2, Figure 4 illustrates the beam profiles for the two probe conditions on the 6.4 mm plate and indicates that the pressure boundary dimensions of the smaller probe are significantly smaller than the larger probe. Appendix 2, Figure 5 illustrates the beam sizes on the entry surface and skip surface, from which it can be seen that although the length dimension is similar the width of the beam for the smaller probe is 2.5 times smaller than for the large diameter probe.

FIGURE 1
Ultrasonic Inspection of Tee and Corner Welds *(1 September 2011)*

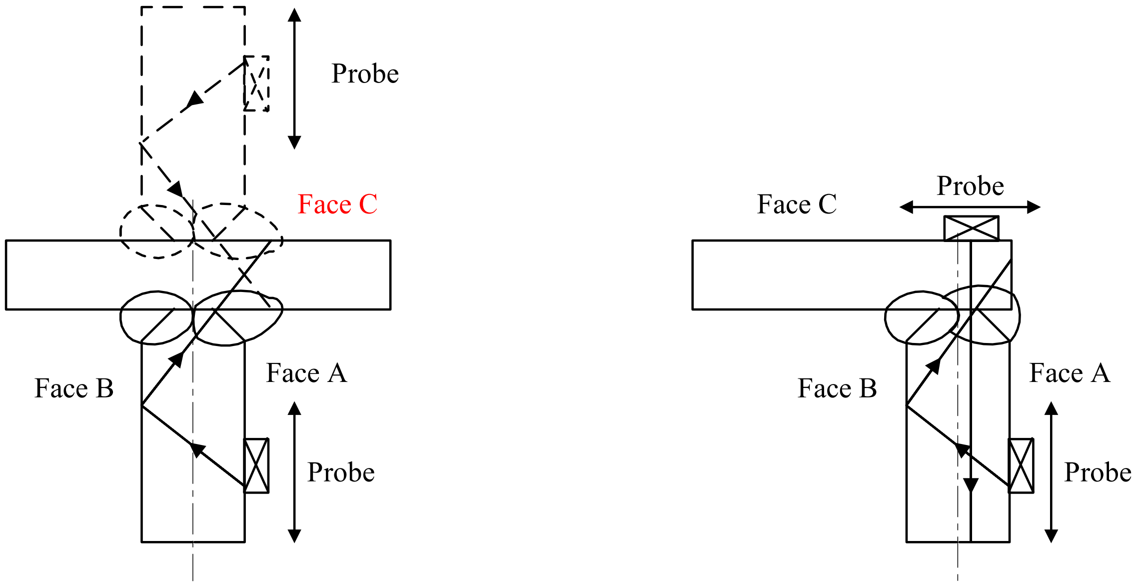


FIGURE 2
Near Zone Positions for 12.5 mm Diameter Element and 6.4 mm Diameter Element Probes *(1 September 2011)*

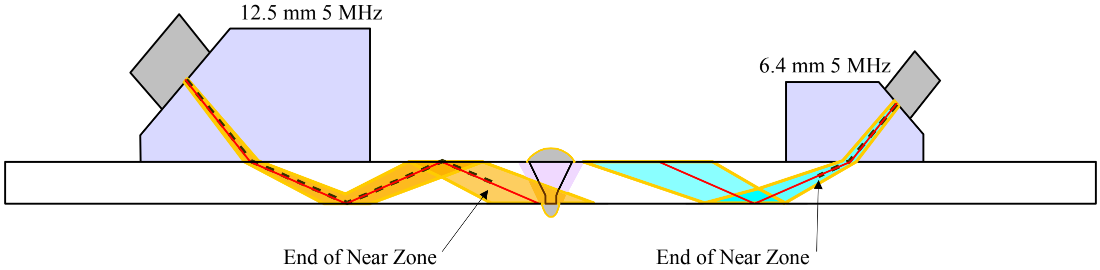


FIGURE 3
Nearest Proximity Restrictions with Large Probe Dimensions *(1 September 2011)*

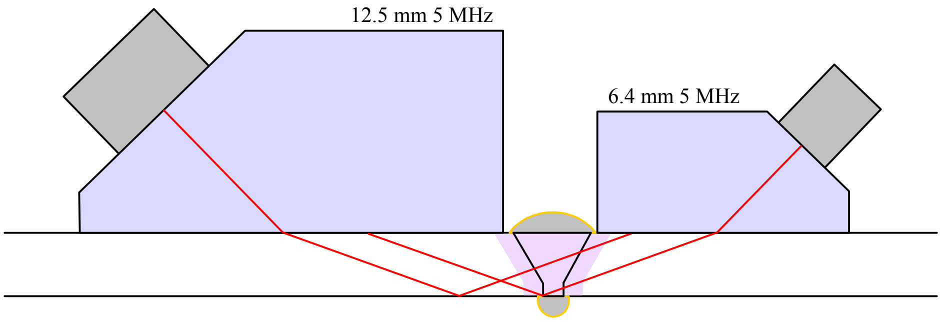
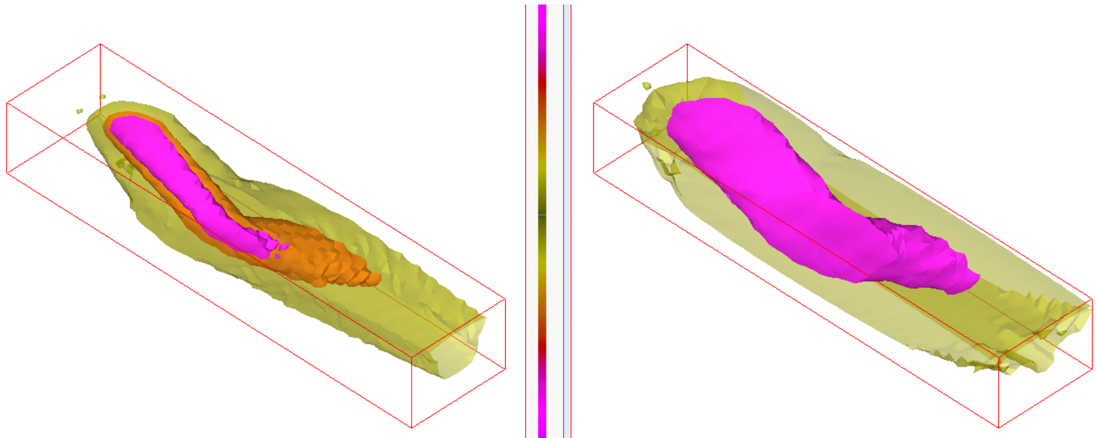
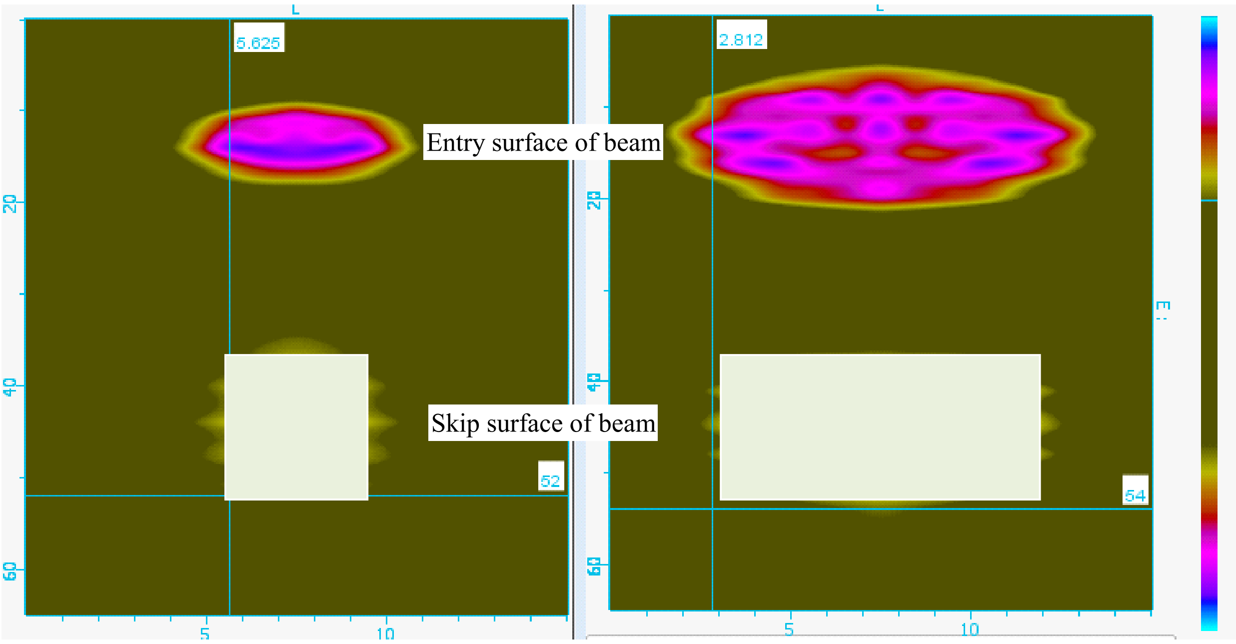


FIGURE 4
Probe Beam Pressure Maps Normalized to the 6.4 mm Diameter Element
(1 September 2011)



6.4 mm diameter element 12.5 mm diameter element

FIGURE 5
Probe Beam Surface Pressure Maps *(1 September 2011)*



6.4 mm diameter element 12.5 mm diameter element

APPENDIX 3 **Guidance for Monitoring Underwater Inspections**

1 General

(1 September 2011) This Appendix is intended for guidance for underwater inspection for ships in lieu of drydocking, mobile or fixed offshore units and other marine and offshore structures. In all cases, the Rules pertinent to the structure and applicable regulations are to be consulted.

The Surveyors should be satisfied that the chosen diving inspection company is competent, that the divers and top-side technicians are qualified for the operation and the equipment to be used is appropriate for the particular survey. Appendix 3, Figures 1 and 2 provide sample inspection and preplanning checklists, and are intended as guidance. The items in the checklist are essentially amplifications of the general remarks contained in the text of this Appendix.

The diving company is required to have a well-defined cleaning/inspection procedure available, as well as an inspection schedule. The intended nondestructive testing methods are to be discussed with the Surveyor prior to the inspection to reduce the likelihood of misunderstandings during the diving operation and expedite the entire operation.

As a minimum, underwater examination consists of a visual inspection. ABS may on occasion require other nondestructive inspection methods [e.g., magnetic particle testing (MT), ultrasonic testing (UT)] for certain joints and designs. Also, an Owner/operator may specify methods other than visual examination. Depending on the intended nondestructive inspection method, the following should be given consideration.

1.1 Visual Inspection *(1 September 2011)*

When a visual inspection (see Appendix 3, Figure 3) is scheduled, a diver who regularly wears glasses or contact lenses should also wear them when diving. Adequate white light is needed for proper inspection. Water clarity with or without artificial lighting is to be sufficient to allow viewing from approximately 1 m (39 in.) or more.

A suitable closed-circuit television with two-way communication capable of being monitored by the Surveyor and/or a still photographic camera capable of providing good resolution photographs should be used. The methods for identifying the inspected area, acceptable quality of video and still photography and the extent of retaining permanent record is to be established before commencement of inspection.

Proper cleaning equipment must be available (e.g. wire brush, preferably hydraulic powered water blast). If the areas required to be cleaned are difficult to reach, a needle gun may be used, provided that precautions are taken so as not to excessively peen the surface. Please note that the use of pneumatic tools may hinder the view of the diver, as well as what is visible on video, by producing excessive bubbling.

1.3 Magnetic Particle Testing (MT) *(1 September 2011)*

MT may be required for a particular application or may be specified by the Owner/operator.

If an MT is to be performed, the surfaces to be examined should be cleaned to bare metal in order to provide good contact and sensitivity. However, a thin protective coating on the surface area to be inspected may be acceptable provided the equipment used has good metal to poles contact (bare metal).

Prior to diving, the proper working conditions of the MT equipment should be verified by the Surveyor. Appendix 3, Figure 4 provides a form of Magnetic Particle Testing (MT). If DC current or permanent magnets are used, the equipment should be demonstrated as capable of lifting 40 lbs in air, 10 lbs if AC current is used. Fixed electromagnetic yokes and permanent magnet yokes do not lend themselves to all geometries encountered and particular attention should be paid to the connection geometry vis-à-vis the surface contact provided by the yokes. For example, although all the MT methods mentioned earlier are generally acceptable for detection of cracks in ferromagnetic materials, the AC method has been proven to be the most sensitive for detection of cracks open to the surface. When using the coil method, amperage is to be in accordance with ASTM E709 or its equivalent.

In addition, the concentration of the testing medium should be checked by use of a magnetic field indicator when utilizing a squirt bottle and with a centrifuge tube when an agitated tank is used. A magnetic field indicator is a pocket tool containing simulated cracks.

When the divers can clearly discern particles deposited and remaining on the magnetic field indicator along the appropriate linear direction, all of the following conditions are satisfactory:

i) Adequacy of particle concentration

ii) Adequacy of field strength

iii) Field direction or orientation of detectable discontinuities

iv) Adequacy of working conditions (e.g., visibility, turbulence)

The diver should carry the magnetic field indicator with him while diving to enable him to verify the adequacy of these conditions regularly.

Depending on the type of magnetic particles (visible or fluorescent) the Surveyor should be satisfied that the proper lighting condition is available: when using visible dye, the conditions should generally be the same as for visual inspection; when using a fluorescent dye, 125 foot-candles at 15 inches (equivalent to 120 $\mu W/cm^2$ at 38 cm) from the ultraviolet light source is considered adequate. Fluorescent indications should be readily discernable on the magnetic field indicator from approximately 1 m (39 in.).

1.5 Alternative and Supplementary NDT Methods

Under some conditions, alternative inspection methods to supplement MT (e.g., eddy current) may be used. Any new technique must work side-by-side with MT until such time as it is proven to the Surveyor's satisfaction that it is equally effective in detecting discontinuities under the conditions encountered with the inspection under consideration. A reasonable amount of MT is to be conducted periodically to verify the supplementary method. In addition, if an alternate method to MT is used, the proposed method and procedure is subject to special approval by the Surveyor.

Ultrasonic examination may be used for crack depth determination provided that MT or an equivalent approved surface crack detection method is used to locate the crack and to verify that it has been removed.

1.7 Ultrasonic Thickness Gauging *(1 September 2011)*

When thickness gauging (Appendix 3, Figure 4) is to be performed using ultrasonic methods, the surfaces of the part to be measured should be cleaned to bright metal to provide a good probe-to-metal contact. Utilized equipment should be calibrated both topside and below the waterline at the inspection depth. Recognized standard blocks should be used for this calibration.

1.9 Reporting

Reporting is to be as per existing practice. Appropriate figures of this Appendix may be used for guidance.

FIGURE 1
Checklist for Underwater Inspection

General

Date ________________

Vessel ____

Location ____

Inspection Company ____

Address ____

____

Telephone ____

Head of diving/inspection operation ____

____

____

____

Persons contacted (including Owner reps., Government agencies, etc.)

____

____

____

____

____

ABS Surveyors ____

____

____

Method(s) of inspection to be used on this survey

________________ Visual

________________ Magnetic particle

________________ Ultrasonic thickness

________________ Other ________________________________
Specify

FIGURE 2
Preplanning Checklist

Personnel

Top-side technicians

Names ____

____

____

NDT method(s) and qualification level

____

____

____

Diver/inspector

Names ____

____

____

NDT method(s) and qualification level

____

____

____

Inspection procedure on board?	Yes ___________	No ___________
Procedure reviewed by Surveyor?	Yes ___________	No ___________
Personnel files of divers and top-side technicians have been reviewed by Surveyor?	Yes ___________	No ___________
Do divers and top-side technicians have proof of level of certification?	Yes ___________	No ___________
Is there a procedure to clearly locate and identify the inspection area?	Yes ___________	No ___________

FIGURE 3
Visual Inspection

Procedure no. ______________________________

Diving conditions (describe)

Weather ______________________________

Water surge ______________________________

Water visibility ______________________________

Depth ______________________________

Inspection equipment used (describe)

Video ______________________________

Still photography ______________________________

Oral communication ______________________________

Lighting ______________________________

Measuring tape ______________________________

Fillet gauge ______________________________

Pit gauge ______________________________

Other ______________________________
Specify

Cleaning equipment used (describe)

Water blast __________ Water blast with grit __________ Needle gun __________

Wire brush: pneumatic __________ hydraulic __________ Other ______________________________
Specify

FIGURE 4
Magnetic Particle Testing (MT) *(1 September 2011)*

Procedure no.____

Magnetic particle method and equipment (check)

Yoke type ______ fixed ______ articulated

Current ______ AC ______ DC

Permanent magnets ______

Coils (AC/DC) ______

Magnetic particle type (check)

Visible (powder color)____________________ Fluorescent___________

Lighting used

White light___________ Black light (UV) _________

Calibration equipment (check)

Ammeter __________ Magnetic field indicator __________ Centrifuge tube __________

10-lb weight__________ 40-lb weight __________ Other ___________________________________
Specify

Cleaning equipment used (check)

Water blast___________ Water blast with grit__________ Needle gun __________

Wire brush: pneumatic __________ hydraulic _________ Other ______________________________
Specify

FIGURE 5
Ultrasonic Thickness Gauging

Procedure no. ______________________________

Diving conditions (describe)

Weather ______________________________

Water surge ______________________________

Water visibility ______________________________

Depth ______________________________

Equipment

Make and model ______________________________

Date of calibration ______________________________

Transducer: make, size and frequency ______________________________

Calibration equipment

IIW block __________ Other ______________________________
Specify

Cleaning equipment used (check)

Water blast __________ Water blast with grit __________ Needle gun __________

Wire brush: pneumatic __________ hydraulic __________ Other ______________________________
Specify

FIGURE 6
Reporting Requirements

The data report sheets generated by the alternating current field measurement examination are to be specifically designed with the system and current examination requirements in mind. The essential information contained on a data sheet is to include:

General Information

Date
Operator's Name
Probe Operator
Component ID Number
File Number
Equipment Used

Scanning Data

Filename
Page Number
Position on Weld
Probe Number
Probe Direction
Tape Position
Examination Summary

Detailed Record of Indications/Anomalies

Filename
Page Number
Position on Weld
Start of Flaw (Tape reference)
End of Flaw (Tape reference)
Length of Flaw (millimeters/inches)
Remarks
Diagram/Drawing of component under examination

APPENDIX 4 Guidance Criteria for Nondestructive Tests Not Required by ABS

1 General

In the course of new construction or after various periods of service, an Owner or shipyard, on their own initiative, may conduct radiographic or ultrasonic inspections of welds in addition to those specified in this Guide or required by the Surveyor. Although such inspections of welds are not required by ABS, there are circumstances under which guidance is desired as to appropriate acceptance criteria. In some instances, the guidance in the table below indicates criteria that have been used by some shipyards and Owners.

Location		*Intersections*	*Butts between Intersections*	*Seams between Intersection*
Outer hull	Midship 0.6*L*	Class A	Twice Class A	Twice Class B
	Outside midship 0.6*L*	Class B	Twice Class B	Twice Class B
Longitudinal and transverse bulkheads and analogous internal structures	Midship 0.6*L*	Class A	Twice Class B	Twice Class B
	Outside midship 0.6*L*	Class B	Twice Class B	Twice Class B