طرح نگهداشت و افزایش تولید ۲۷ مخزن

NDT PROCEDURE (TOWER, COLUMNS, REBOILER, DRUMS, FILTERS & EXCHANGERS)

نگهداشت و افزایش تولید میدان نفتی بینک

V00	MAY. 2024	IFA	MFS	M.Fakharian	S.Faramarzpour	
Rev.	**Date**	**Purpose of Issue/Status**	**Prepared by:**	**Checked by:**	**Approved by:**	**CLIENT Approval**

Status:

IFA: Issued For Approval
IFI: Issued For Information
AFC: Approved For Construction

پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه
BK	GCS	MF	120	QC	PR	0009	V00

REVISION RECORD SHEET

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1. PURPOSE

- This procedure describes the requirements and techniques for manual ultrasonic testing of ferrous materials.
- The application of this procedure is limited to straight beam (using normal probes that transmit longitudinal waves into metal) and angle beam (using angle probes that transmit transverse/shear waves into metal) methods of ultrasonically testing the welded joints, heat affected zone and adjacent base material surfaces using manual contact and pulse-echo ultrasonic techniques.

2. DEFINITIONS

CLIENT:	**National Iranian South Oilfields Company (NISOC)**
PROJECT:	**Binak Oilfield Development – General Facilities**
EPD/EPC CONTRACTOR (GC):	**Petro Iran Development Company (PEDCO)**
EPC CONTRACTOR:	**Joint Venture of: Hirgan Energy– Design & Inspection(D&I) Companies**
VENDOR:	**MFS Co.**

3. REFERENC DOCUMENT

- ASME BPVC SEC. V_2021
- ASME BPVC SEC VIII, DIV. 1_2021
- ASNT, SNT-TC-1A (2021)
- SPECIFICATION FOR PRESSURE VESSELS (Doc No.: BK-00-GNRAL-000-ME-SP-0001-D03)

4. GENERAL REQUIREMENTS

- Ultrasonic examination shall be performed in accordance with a written procedure which shall, as a minimum, contain the requirements listed in the following Table.
- When procedure qualification is specified by the referencing Code Section, a change of a requirement in this Table identified as an essential variable from the specified value, or range of values, shall require requalification of the written procedure. A change of a requirement identified as a nonessential variable from the specified value, or range of values, does not require requalification of the written procedure.

5. QUALIFICATION OF PERSONNEL

- Personnel performing the nondestructive examination shall be qualified in accordance with the requirements of ASNT SNT-TC-1A and ASME code.
- Only qualified and certified Level II or Level III personnel shall test all examination and evaluation.

Requirement	Essential	Non-essential	Applicable paragraph
Weld configurations to be examined, including thickness dimensions and base material product form (pipe, plate, etc.)	×		15
The surfaces from which the examination shall be performed	×		1.2
Technique(s) (straight beam, angle beam, contact, and/or immersion)	×		1.2
Angle(s) and mode(s) of wave propagation in the material	×		1.2
Search unit type(s), frequency(ies), and element size(s)/shape(s)	×		6.3
Special search units, wedges, shoes, or saddles, when used	N.A.		
Ultrasonic instruments	×		6.1
Calibration (blocks and techniques)	×		7
Directions and extent of scanning	×		6.3
Scanning (manual vs. automatic)	×		1.1
Method for discriminating geometric from flaw indications	×		13
Method for sizing indications	×		14
Computer enhanced data acquisition, when used	N.A.		
Scan overlap (decrease only)	×		6.3.1
Personnel performance requirement	×		5.1
Personal qualification requirement		×	5.2
Surface condition (Examination surface and calibration block)		×	6.6
Couplant (Brand and type)		×	6.2
Post-examination cleaning technique		×	9
Automatic alarm and/or recording equipment, when applicable	N.A.		
Records, including minimum calibration data to be recorded (e.g., instrument settings)		×	17

6. GENERAL REQUIREMENTS

1.1 6.1. EQUIPMENT

- The instrument shall be capable of operation at test frequency over the range 1 MHz to 5 MHz and equipped with a stepped gain control calibrated in units of 2.0 dB or less.

1.2 6.2. COUPLANT

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

- Suitable liquid, such as liquid soap, machine oil, glycerin or water, shall be used as a couplant.

1.3 6.3. EXAMINATION COVERAGE

- The volume to be scanned shall be examined by moving the search unit over the examination surface so as to scan the entire examination volume. The weld joint plus 10 mm of base material adjust to HAZ shall be 100% examined with straight and angle beam search unit. Each pass of the search unit shall overlap a minimum of 10% of the transducer (piezoelectric element) dimension parallel to the direction of the scan. Our available probes are Probe 60 / 5 MHz, Probe 45 / 5 MHz, Probe 45 / 2.3MHz, Probe Normal & Probe TR. The weld joint plus 10 mm of base material adjust to HAZ shall be 100% examined with straight and angle beam search unit (for excess 25 mm wall thickness).

1.4 6.4. PULSE REPETITION RATE

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

1.5 6.5 RATE OF SEARCH UNIT MOVEMENT

6.5.1 The rate of search unit movement (scanning speed) shall not exceed 150 mm/sec. unless:

- The ultrasonic instrument pulse repetition rate is sufficient to pulse the search unit at least six times within the time necessary to one-half the transducer dimension parallel to the direction of the scan at maximum scanning speed; or,
- A dynamic calibration is performed on multiple reflectors, which are within ±2 dB of a static calibration and the pulse repetition rate meets the requirements of Para.

1.6 6.6. SURFACE PREPARATION

- The base metal on each side of the weld shall be free of weld spatter, surface irregularities, loose foreign matter or coatings which might interfere with the examination.
- Post examination cleaning includes de-greasing and cleaning of the used grease with a suitable material.
- When the weld surface interferes with the examination, the weld shall be prepared as needed to permit the examination. Preparation of a weld seams by grinding or machining may be required where surface irregularities would mask indications of unacceptable discontinuities.
- The area adjacent to the weld shall be prepared for at least 3 times thickness of material under test both side of weld for smooth scanning surface.

1.7 6.7 CALIBRATION REFERENCE STANDARDS (REFERENCE BLOCK)

6.7.1 Basic calibration reflectors

- The basic calibration reflectors shall be used to establish a primary reference response of the equipment. The basic calibration reflectors may be located either in the component material or in a basic calibration block.

6.7.2 Basic calibration block

- The material from which the block is fabricated shall be of the same product form and material specification or equivalent P-No grouping as one of the materials being examined. For the purpose of this paragraph, P-Nos. 1, 3, 4 and 5 materials are considered equivalent.
- For examinations in welds where the examination surface diameter is greater than 500 mm, a flat basic calibration block shall be used. If the welds with diameter 500 mm or less, a single curved basic calibration block shall be used to calibrate the examination on surface in the range of curvature from 0.9 to 1.5 times the basic calibration block diameter.

6.7.3 Cylindrical surfaces calibration block according to article4 of ASME sec v appendix M

- This is a more compact form of the V1 block suitable for site use, although somewhat less versatile in its function. It is also described by International Institute of Welding (I.I.W). The latest version of this block. It is particularly suitable for short near field lengths and the time base calibration of small diameter normal and angle probes.

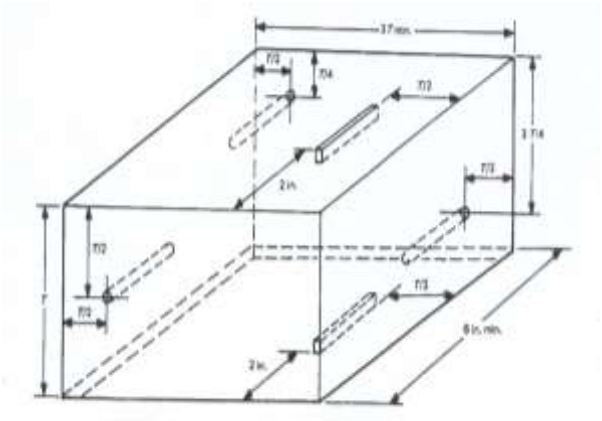
7. CALIBRATION

1.8 7.1 CHECKING & CALIBRATION OF EQUIPMENT

- The proper functioning of the examination equipment shall be checked and the equipment shall be calibrated by the use of the calibration standard at the beginning and end of each examination

7.2 BASIC CALIBRATION BLOCK

7.2.1. The basic calibration reflectors shall be used to establish a primary reference response of the equipment. The basic calibration reflectors may be located either in the component material or in a basic calibration block.



Weld Thickness (t), in (mm)	Basic Calibration Block Thick (T), in (mm)	Hole Diameter in (mm)	Notch Size in (mm)
≤1 (≤25)	¾ (19) or t	3/32 (2.5)	Notch depth = 1.6% T to 2.2% T

>1 (>25) through 2 (50)	**1 ½ (38) or t**	**1/8 (3)**	**Notch width = 1/4 (6) max. Notch length = 1 (25) min.**
>2 (>50) through 4 (100)	**3 (75) or t**	**3/16 (5)**	

NOTE:

- Holes shall be drilled and reamed 1.5 in. (38 mm) deep minimum, essentially parallel to the examination surface.
- For blocks less than 3/4 in. (19 mm) in thickness, only the 1/2T side-drilled hole and surface notches are required.
- The tolerance for hole diameter shall be ± 1/32 in (0.8 mm)
- The tolerance on notch depth shall be + 10% and –20%
- The tolerance on hole location through the thickness shall be ± 1/8 in (3 mm)

7.2.2. Angle Beam Calibration:

The Calibration shall provide the following measurements:

a) Distance range condition

b) Distance – Amplitude

c) Echo amplitude measurement from the surface notch in the basic calibration block.

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

7.2.3 Straight Beam Calibration:

The calibration shall provide the following measurements.

a) Distance range calibration

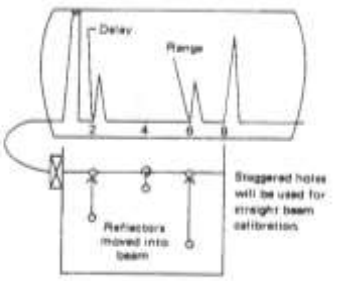
b) Distance-amplitude correction in the area of interest

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

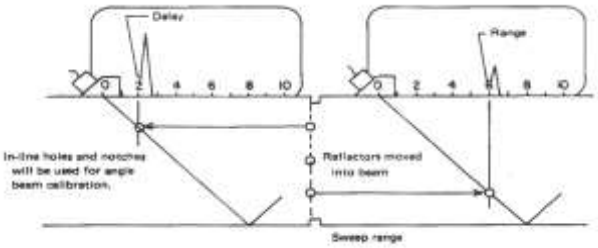
1.9 7.3 CALIBRATION CONFIRMATION

- Calibration shall be performed prior to use of the system in the thickness range under examination. A calibration check shall verify the sweep range calibration and distance-amplitude correction as defined in (ASME Sec V Article 5).
- Re-calibration of the ultrasonic system shall be performed if; A change in operator, power supply, search unit, frequency, cables, couplant, or other components occurs. The calibration shall be done prior to examination, after each five (5) hours and the end of each examination.
- Distance Range Points
- If any distance range point on the DAC curve has moved on the sweep line by more than 10% of the distance reading or 5% of full sweep (whichever is greater), correct the distance range calibration and note the correction in the examination record. If reflectors are recorded on the data sheets, those data sheets shall be voided and a new calibration shall be recorded. All recorded

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



Angle-Beam

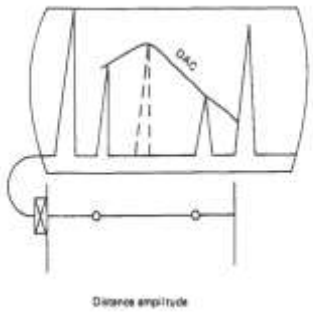


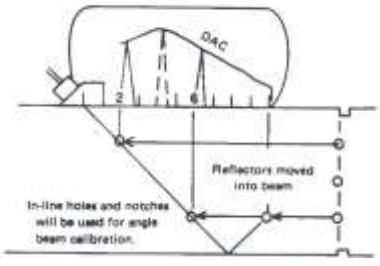
Straight – Beam

Sweep-range

- DAC Correction

  If a point on the distance –amplitude correction (DAC) curve has decreased 20% or 2 dB of its amplitude, all data sheets since the last calibration or calibration check shall be marked void. A new calibration shall be made and recorded and the area covered by the voided data shall be reexamined. If any point of the distance-amplitude correction (DAC) curve has increased more than 20% or 2 dB of its amplitude, all recorded indications since the last valid calibration or calibration check shall be reexamined with the corrected calibration and their values shall be changed on the data sheet.





Straight-Beam Angle-Beam

Distance-Amplitude Correction

8. EXAMINATION PROCEDURE

1.10 8.1 SCANNING SENSITIVITY LEVEL

- **Distance Amplitude Techniques.** The scanning sensitivity level shall be set a minimum of 6 dB higher than the reference level gain setting.
- Non-Distance Amplitude Techniques**. The level of gain used for scanning shall be appropriate for the configuration being examined and shall be capable of detecting the calibration reflectors at the maximum scanning speed**

1.11 8.2 STRAIGHT BEAM

- The scanning of the adjacent base metal shall be performed to detect reflectors that might affect interpretation of angle beam result, and is not to be used as an acceptance rejection examination. Locations and areas of such reflector shall be record. The weld and base metal shall be scanned, where required by the referencing code section to the extent possible with the straight beam search unit. The scanning shall be performed at a gain setting of at least two times the primary reference level. Evaluation shall be performed with respect to the primary reference level.

1.12 8.3. ANGLE BEAM SCANNING FOR REFLECTORS ORIENTED PARALLEL TO THE WELD

- The angle beam shall be directed at approximate right angles to the weld axis from two directions where possible. The search unit shall be manipulated so that the ultrasonic energy passes through the required volumes of weld and adjacent base metal.
- The scanning shall be performed at again setting at least two times the primary reference level. Evaluation shall be performed with respect to the primary reference level.

1.13 8.4. ANGLE BEAM SCANNING FOR REFLECTORS ORIENTED TRANSVERSE TO THE WELD

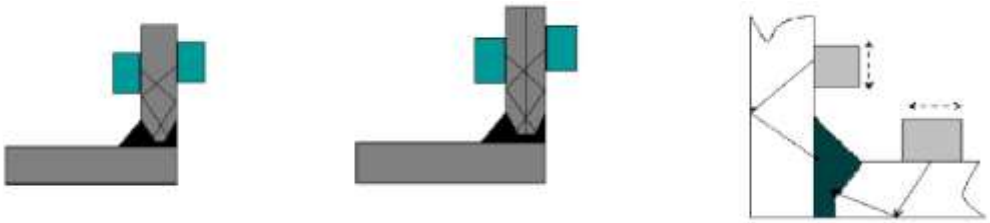
The angle beam shall be directed essentially parallel to the weld axis. The search unit shall be manipulated so that the ultrasonic energy passes through the required volumes of weld and adjacent base metal specified by the referencing code section. The search unit shall be rotated 180 deg. and the examination repeated.

9. POST-EXAMINATION CLEANING

It shall be conducted as soon as practical after evaluation and documentation using a process that does not adversely affect the part.

10. PROBE PLACEMENT FOR WELD CONFIGURATION

The following figures demonstrate preferred probe placement for weld configuration. Usually, two shear angles are used for a proper inspection. For thicknesses under about 20 mm a 60˚ and 70˚ probe would be used.



11. EVALUATION OF IMPERFECTIONS

1) It is recognized that not all ultrasonic reflectors indicate flaws, since certain metallurgical discontinuities and geometric conditions may produce indications that are not relevant. Included in this category are plate segregates in the heat-affected zone that become reflective after fabrication. Under straight beam examination, these may appear as spot or line indications. Under angle beam examination, indications that are determined to originate from surface conditions (such as weld root geometry) or variations in metallurgical structure in austenitic materials (such as the automatic-to-manual weld clad interface) may be classified as geometric indications.
2) The following steps shall be taken to classify an indication as geometric:

- Interpret the area containing the reflector in accordance with the applicable examination procedure.
- Plot and verify the reflector coordinates. Prepare a cross-sectional sketch showing the reflector position and surface discontinuities such as root and counterbore.
- Review fabrication or weld preparation drawings. Other ultrasonic techniques or nondestructive examination methods may be helpful in determining a reflector's true position, size, and orientation.
- All indications greater than 20% of the reference level shall be investigated to the extent that they can be evaluated in terms of the acceptance criteria of the referencing Code Section.

12. ACCEPTANCE CRITERIA

- All imperfections, which produce amplitude greater than 20% of the reference level, shall be investigated to the extent that the operator can determine the shape, identity and location of all such imperfections and evaluate them in terms of the following acceptance standards.
- Imperfections that are interpreted to be crack, lack of fusion, or incomplete penetration are unacceptable regardless of length.
- Other imperfections are unacceptable if the amplitude exceeds the reference level and the length of the imperfection exceeds the following:
- a) ¼ in (6.0 mm) for t up to ¾ in (19.0 mm).
- b) 1/3 t for from 3/4 in (19.0 mm) to 2¼ in (57.0 mm)
- b) ¾ in (19.0 mm) for t over 2¼ in (57.0 mm)
- Where the thickness of the weld excluding any allowable reinforcement. For a butt weld joining two members having different thickness at the weld, t is the thinner of these two thicknesses. If a full penetration weld includes a fillet weld, the thickness of the throat of the fillet shall be included in t.

13. METHOD FOR DISCRIMINATING GEOMETRIC FROM FLOW INDICATION

- Linear indication such as cracks (transfer & longitudinal), lack of penetration, lack of fusion and slag line produce single very sharp and height flow indication that when search unit swing around the defect's location cause immediate drop of related echo in ultrasonic testing display device.
- Rounded indication such as isolated porosity & slag produce single low gain flow indication that when search unit swing around the defect's location, related echo in ultrasonic testing display device not eliminate immediately.
- Rounded indication such as cluster porosity produce multi-flow indication like a grass & noise.
- Location (depth & distance) of all above indication shall be investigate & interpret ate by estimation of maximum sound path of related indication.
- False and non-relevant indication shall be separate by relevant indication with interpretation of the depth, location, height of related echo, ….by expert ultrasonic testing operator.

14. METHOD FOR SIZING INDICATIONS

- For normal & angel beam ultrasonic testing inspection, method of sizing indication is half value method measurement (6 dB drop) as follow:
- The size of reflectors which are large is comparison to the sound beam diameter can be determines by edge scanning probe is moved from a position which provides the optimum flaw echo to the edge of the flaw. The point at which the echo height is half the optimum value, i.e., where the beam axis is incident on the edge of the flow, is marked on the testing surface. A series of such point outline the reflector surface.
- The half value length (HVL) is the distance measured on the test object between edge point in a longitudinal direction, the half value width (HVW) in a normal direction.
- The 6 dB technique involves obtaining an echo from a position where the reflector extends across the full width of ultrasonic beam and then moving the beam along the reflector until the echo has fallen by half (i.e., by 6 dB).it is then assumed that only one half of the beam is impinging on the reflector whose edge, therefore, lies along the beam axis. The technique is applicable to both normal & angel probes, and is most frequently used for the potting of lamination in plate, and for measuring the length of linear imperfection in welds.

15. REPAIR & RE-EXAMINATION

- Where defects are unacceptable, the location shall be removed and weld repair done. Re-examination of the repaired weld seam shall be done accordingly.

16. RECORDS

Examination report shall include the information below, as minimum.

a) Procedure

b) Ultrasonic examination system (equipment)
c) Identification and location of weld or volume scanned.
d) Date of the examination was performed.
e) Surface condition
f) Frequency.
g) Sketch showing joint configuration.
h) Material thickness.

17. APPENDIX

Sample of UT report has been attached on the next page.

پروژه	بسته کاری	صادرکننده	تسهیلات	رشته	نوع مدرک	سریال	نسخه
BK	GCS	MF	120	QC	PR	0009	V00

کد سند مرجع : PR-01-10 شماره بازنگری : ۰۴ تاریخ تهیه/ بازنگری : ۱۴۰۱/۰۴/۲۵	گزارش تست التراسونیک ULTRASONIC TEST REPORT	MFS
تاریخ تهیه/ بازنگری: ۱۴۰۱/۰۴/۲۵	شماره بازنگری: ۰۱	کد فرم: FR-08-01/51

ITEM&NAME NO.:			PROJECT:											PAGE : OF		
PROCEDURE NO.:			MATERIAL:						CODE/STANDARD: ASME SEC V					REPORT NO:		
TIME OF EXAMINATION (زمان آزمایش):																
SURFACE CONDITION(شرایط سطح): ☐AS WELDED(جوشکاری شده) ☐AS FORGED(فورج) ☐AS CASTED(ریخته گری) ☐AS MACHINED(ماشین کاری) ☐AS GROUND(سنگ کاری) ☐ OTHER																
WELDING PROGRESS: ☐SMAW ☐GTAW ☐GMAW ☐FCAW ☐SAW ☐OTHER									GROOVE TYPE : ☐V ☐U ☐X ☐K ☐ OTHER							
EQUIPMENT(تجهیز): MAKER (مولد):SONA TEST MODEL (مدل): 250s			SEARCH UNIT(واحد جستجو): MAKER (مولد):SONA TEST						FREQUENCY (MHZ) (فرکانس): 4&5MHZ / SIZE Ø (MM):10&10&8*9							
TEST BLOCKS(بلوک تست): CALIBRATION BLOCKS (بلوک کالیبراسیون):IIW V1 & ASME DAC ☐BASIC MATERIAL (متریال پایه)									CUPLANT(کوپلانت): ☐ OIL (روغن) ☐ GREASE(گریس) ☐ GLYCERIN (گلیسیرین) ☐ SCA (SCA) ☐WATER (آب) ☐OTHER (سایر)							
EXAMINATION METHOD(روش آزمایش): ☐PULSE ECHO (پالس اکو) ☐STRAIGHT BEAM (سیگنال مستقیم) ☐CONTACT (اتصال) ☐IMMERSION(شناوری) ☐THROUGH TRANSOMISSION (عبوری) ☐ANGLE BEAM-DEGREE (سیگنال زاویه ای)																
CODE/STANDARD(کد استاندارد)ASME SEC V									PROCEDURE NO.:							
NO	DATE	LINE & LOCATION (خط و محل)	OD (قطر)	THIC (MM) (ضخامت)	MAX HIGHT% (حداکثر ارتفاع)			DISCONTINUITY IDENTIFICATION				RESULT				REMARK (توضیحات)
					80	50	20	POSITION FROM ZERO (X)	LENGHT (MM) (طول) (L)	WIDTH (عرض) (Y)	DEPTH(MM) (عمق) (D)	ACCEPT (قبول)	REPAIR (اصلاح)	AFTER REPAIR: REPAIR	AFTER REPAIR: ACCEPT	
ATTACHMENT : YES☐ NO ☐		AUTHORITY: NAME: SIGNATURE: DATE:										SKETCH :				
EXAMINED BY :																
INTERPRETED BY		MANUFACTURER: NAME: SIGNATURE: DATE:														
APPROVED BY :		PURCHASER: NAME: SIGNATURE: DATE:														
		TPA: NAME: SIGNATURE: DATE:														
CLIENT :		LIDCO: NAME: SIGNATURE: DATE:														

MFS "مدرک معتبر"

RT PROCEDURE

Index Page

1. PURPOSE

This procedure describes the requirements and techniques for radiographic testing of weldments.

2. DEFINITIONS

CLIENT: **National Iranian South Oilfields Company (NISOC)**

PROJECT: **Binak Oilfield Development – General Facilities**

EPD/EPC CONTRACTOR (GC): **Petro Iran Development Company (PEDCO)**

EPC CONTRACTOR: **Joint Venture of: Hirgan Energy – Design & Inspection(D&I) Companies**

VENDOR: **MFS Co.**

3. REFERENC DOCUMENT

- ASME BPVC SEC. V_2017
- ASME BPVC SEC VIII, DIV. 1_2017
- ASNT, SNT-TC-1A (latest edition)
- SPECIFICATION FOR PRESSURE VESSELS (Doc No.: BK-00-GNRAL-000-ME-SP-0001-D03)

4. QUALIFICATION OF PERSONNEL

- The personnel who are performing the radiographic testing to this procedure shall be qualified and certified in accordance with ASNT Recommended Particle NO. SNT-TC-1A.
- Only Level II or III must interpret the radiographs.

5. SAFETY REQUIREMENTS

The radiographer shall be responsible for the radiation protection and radiation monitoring of every person working with or near the radiation source. The radiation protection and monitoring shall be complying with national rules of work with radiation in industrial radiography (Iran nuclear regulatory authority (INRA) - inrarp6cp05 - 03/05/1384).

6. GENERAL REQUIREMENTS

1.14 6.1 SURFACE PREPARATION

Any surface irregularities shall be removed by any suitable process to such a degree that the resulting radiographic image due to irregularities can`t mask or be confused with the image of discontinuity before issue RT request by manufacturer.

1.15 6.2 OVERLAP OF RADIOGRAPHS

In radiographing a continuous length of weldment with separate films, the separate films shall overlap at least 0.4 in (10 mm) whenever possible and practical to ensure that no portion of the weld length remains unexamined.

7. EQUIPMENT AND MATERIALS

1.16 7.1 RADIATION

Radiation source to be used shall be Gamma-ray. Ir-192 source may be used.

1.17 7.2 FILM

Radiographs shall be made using film type that satisfy the density and sensitivity limitation of ASME Sec.5, Article 2. The film is required to be of a sufficient length and width to allow a minimum of 25 mm on consecutive circumferential exposures, and 19 mm coverage on either side of the weld.

The available film brands and types are as follow:

Radiation	Brand	Film Type
Gamma-ray	Foma or Kodak	R7 AA400 MX125

1.18 7.3 INTENSIFYING SCREENS

7.3.1 Lead intensifying screens may be used. All screens should be handled carefully to avoid dents and scratches, dirt, oils and other surface contaminants on active surfaces and free from wrinkles, pits and other mechanically produced defects.

1.19 7.4 PENETROMETER

7.4.1 Design

According to spec, penetrometers (wire-type image quality indicators (IQI)) shall be used. Wire type penetrometers shall be manufactured and identified in accordance with the requirement or alternates allowed in SE-747 except that the largest wire number or the identity number may be omitted.

7.4.2 Selection

7.4.2.1 The designated essential wire shall be as specified in below Table.

Table T-276
IQI Selection

Nominal Single-Wall Material Thickness Range, in. (mm)	IQI					
	Source Side			Film Side		
	Hole-Type Designation	Essential Hole	Wire-Type Essential Wire	Hole-Type Designation	Essential Hole	Wire-Type Essential Wire
Up to 0.25, incl. (6.4)	12	2T	5	10	2T	4
Over 0.25 through 0.375 (6.4 through 9.5)	15	2T	6	12	2T	5
Over 0.375 through 0.50 (9.5 through 12.7)	17	2T	7	15	2T	6
Over 0.50 through 0.75 (12.7 through 19.0)	20	2T	8	17	2T	7
Over 0.75 through 1.00 (19.0 through 25.4)	25	2T	9	20	2T	8
Over 1.00 through 1.50 (25.4 through 38.1)	30	2T	10	25	2T	9
Over 1.50 through 2.00 (38.1 through 50.8)	35	2T	11	30	2T	10
Over 2.00 through 2.50 (50.8 through 63.5)	40	2T	12	35	2T	11
Over 2.50 through 4.00 (63.5 through 101.6)	50	2T	13	40	2T	12
Over 4.00 through 6.00 (101.6 through 152.4)	60	2T	14	50	2T	13
Over 6.00 through 8.00 (152.4 through 203.2)	80	2T	16	60	2T	14
Over 8.00 through 10.00 (203.2 through 254.0)	100	2T	17	80	2T	16
Over 10.00 through 12.00 (254.0 through 304.8)	120	2T	18	100	2T	17
Over 12.00 through 16.00 (304.8 through 406.4)	160	2T	20	120	2T	18
Over 16.00 through 20.00 (406.4 through 508.0)	200	2T	21	160	2T	20

7.4.2.2 Welds with Reinforcements

The thickness on which the penetrometer is based is the nominal single wall thickness plus the estimated weld reinforcement not to exceed the maximum permitted by the referencing code section. Backing rings or strips shall not to be considered as part of the thickness in penetrameter selection. The actual measurement of the weld reinforcement is not required.

7.4.2.3 Welds without Reinforcements

The thickness on which the penetrameter is based is the nominal single wall thickness.

Backing rings or strips shall not be considered as part of the weld thickness in penetrameter selection.

7.4.3 Placement of Penetrometers

7.4.3.1 Source Side Penetrometer

The penetrometer shall be placed on the source side of the part being examined, except for the condition described in 6.5.3.2.

7.4.3.2 Film Side Penetrometer

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

7.4.3.3 Penetrometer Location for Weld-Wire Penetrometers

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

7.4.4 Number of Penetrometers

When one or more film holders are used for an exposure, at least one penetrometer image shall appear on each radiograph except as outlined in 7.4.4.2.

7.4.4.1 Multiple Penetrometers

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

7.4.4.2 Special Case

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

a) When the complete circumference is radiographed using one more film holder, or;

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

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

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

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

(3) Weld are radiographed simultaneously with the circumferential weld an additional penetrometer shall be placed on each longitudinal weld at the end of the section most remote from the junction with the circumferential weld being radiographed.

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

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

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

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

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

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

(8) In order to maintain the continuity of records involving subsequent exposures, all radiographs exhibiting penetrometers which qualify the techniques permitted in accordance with 7.4.4.2 (1) to (6) shall be retained.

8. QUALITY OF RADIOGRAPHS

1.20 8.1 GENERAL

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

1. Fogging
2. Processing defects such as streaks, water marks, or chemical stains
3. Scratches, finger marks, crimps, dirtiness, static marks, smudges, or tears
4. False indications due to defective screens
5. Loss of detail due to poor screen to film contact

1.21 8.2 DENSITY

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

1.22 8.3 SCATTERED RADIATION

8.3.1 As a check on back-scattered radiation, a lead symbol “B” with minimum dimensions of 0.5 in (13 mm) in height and 0.0625 in (1.6 mm) in thickness, shall be attached to the back of each film holder.

8.3.2 If a light image of the “B” appears on a darker background of the radiographic, protection from back-scatter is insufficient and the radiograph shall be considered unacceptable. A dark image of the “B” on a lighter background is not cause for rejection.

9. IDENTIFICATION OF RADIOGRAPHS

1.23 9.1 FILM IDENTIFICATION METHOD

9.1.1 For fabricating identification of examined welds and radiographs, alphabetical letters and numerals shall be affixed on the film. In the case of missing or using wrong letters by radiographer, required information must be written by a permanent pen on the radiographs.

Following information shall be marked on the films:

1. Weld number
2. Welder's symbol
3. Tag number (item number)
4. Project name
5. Project code (133)

9.1.2 Repair or reshoot radiographs shall be identified by R1, R2, R/S, as applicable.

NOTE: Markings shall clear the outer edges of the weld.

10. SHARPNESS OF RADIOGRAPHIC IMAGE

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

$$U = \frac{F \times d}{D}$$

Where:

Ug = geometric unshaprness

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

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

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

10.2 Geometric unsharpness of the radiograph shall not exceed the limitation of the following table.

Material thickness, in (mm)	Ug maximum, in (mm)
1 through 2 in. [25.4 through 51 mm]	0.020 (0.5)
Over 2 through 3 in. [over 51 through 76.0 mm]	0.030 (0.76)
Over 3 through 4 in. [over 76.0 through 100 mm]	0.040 (1.0)
Greater than 4 in. [greater than 100 mm]	0.070 (1.8)

10.3 The exposure time is calculated by following formula:

Exposure time= (gh × s.f.d2 × f.f × 60) / 32000 × ci

gh: will be given from table of weld thickness on the next page

s.f.d.: Source-to-Film Distance

f.f.: Film Factor

ci: source power

Radiation	Brand	Film Type	Film Factor
Gamma-ray	Fuji	IX100	40
	Fuji	IX 80	65
	Kodak	AA400	40
	Kodak	MX125	120

mm	gh	mm	gh	mm	gh	mm	gh	mm	gh
4	1.81	24	4.37	44	10.5	64	25.42	84	61.32
5	1.89	25	4.57	45	11.05	65	25.67	85	64.08
6	1.98	26	4.78	46	11.51	66	27.76	86	66.96
7	2	27	4.99	47	12.03	67	29.01	87	69.97
8	2.16	28	5.21	48	12.58	68	30.32	88	73.12
9	2.26	29	5.46	49	13.3	69	31.68	89	76.41
10	2.36	30	5.69	50	13.73	70	33.11	90	79.85
11	2.47	31	5.95	51	14.34	71	34.6	91	83.44
12	2.57	32	6.22	52	14.99	72	36.15	92	87.2
13	2.7	33	6.2	53	15.66	73	37.78	93	91.12
14	2.82	34	6.79	54	16.37	74	39.48	64	95.23
15	3.94	35	7.09	55	17.1	75	41.26	95	99.51
16	3.07	36	7.41	56	17.87	76	43.12	96	103.99
17	3.21	37	7.75	57	18.68	77	45.06	97	108.67
18	3.36	38	8.1	58	19.52	78	47.08	98	113.56
19	3.5	39	8.46	59	20.4	79	49.2	99	118.67
20	3.67	40	8.84	60	21.32	80	51.42	100	124.01
21	3.83	41	9.23	61	22.38	81	53.73		
22	4	42	9.64	62	23.28	82	56.15		
23	4.18	43	10.05	63	24.33	83	58.68		

11. RADIOGRAPHIC TECHNIQUE

1.24 11.1 SINGLE-WALL TECHNIQUE

11.1.1 A single wall exposure technique shall be used for radiography whenever practicable as shown in Fig. 1, (a) (b) (c). When it is not practical to use a single-wall technique, a double-wall technique shall be used. An adequate number of exposures shall be made to demonstrate that the required coverage has been obtained.

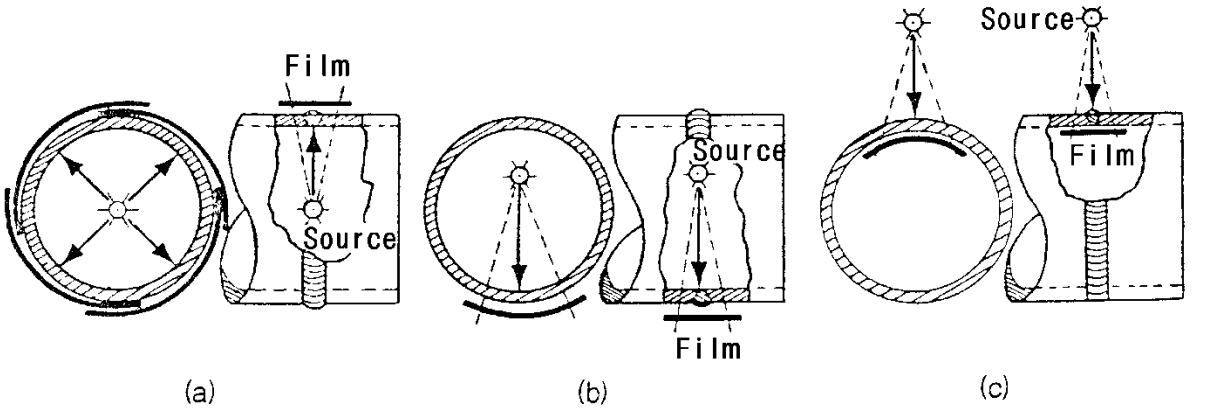


Fig. 1 Single-Wall Radiographic Techniques

1.25 11.2 DOUBLE-WALL TECHNIQUE

11.2.1 Single-Wall Viewing

For materials and for welds in components, a technique may be used in which the radiation passes through two walls and only the weld (material) on the film side wall is viewed for acceptance on the radiograph. When complete coverage is required for circumferential welds (materials), a minimum of three exposures taken 120deg. to each other shall be made (See Fig. 2, (a) (b)).

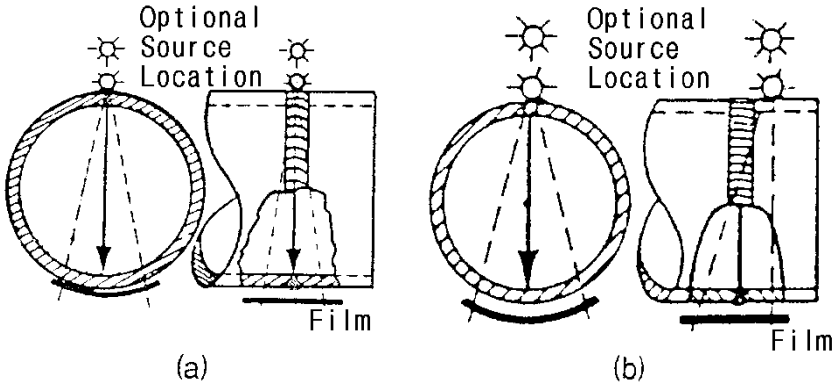


Fig.2 Double-Wall Exposure, Single-Wall Viewing

11.2.2 Double-Wall Viewing

For materials and for welds in components 3½ in or less in nominal outside diameter, a technique may be used in which the radiation passes through two walls and the weld(material) in both walls in viewed for acceptance on the same radiograph. For double-wall viewing, only a source side penetrometer shall be used. Care should be exercised to ensure that the required geometric unsharpness is not exceeded. If the geometric unsharpness requirement cannot be met, then single-wall viewing shall be used.

1. For welds, the radiation beam may be offset from the plane of the weld at an angle sufficient to separate the images of the source side and film side portions of weld so that there is no overlap of the areas to be interpreted. When complete coverage is required, a minimum of two exposures taken 90deg. to each other shall be made for each joint. (See Fig. 5)
2. As an alternative, the weld may be radiographed with the radiation beam positioned so that the images of both walls are superimposed. When complete coverage is required, a minimum of three exposures taken at either 60 deg. or 120 deg. to each other shall be made for each joint. (See Fig. 6)
3. Additional exposures shall be made if the required radiographic coverage cannot be obtained using the minimum number of exposures indicated in para. 11.2.2 (1) or (2).

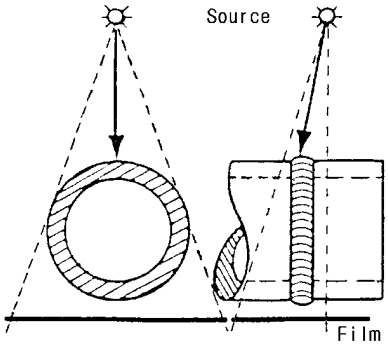


Fig. 3 Double-Wall Exposure, Double-Wall Viewing
(3½ in or less, at least 2 exposures at 90 deg. to each other,
ellipse read offset source side and film side images)

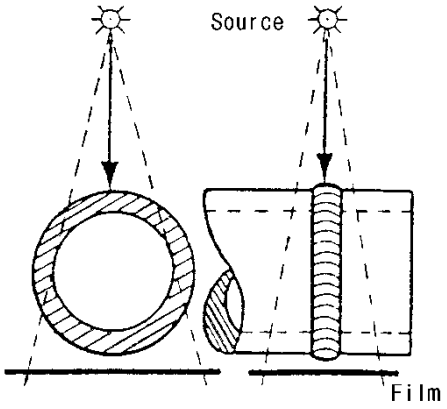


Fig. 4 Double-Wall Exposure, Double-Wall Viewing
(3½ in or less, at least 3 exposures at 60 deg. or 120 deg. to each other,

read superimposed source side and film side images)

12. FILM PROCESSING

1.26 12.1 DEVELOPMENT

12.1.1 Normal development is 5 to 8 min at 68 °F (20 °C). When the temperature is higher or lower, development time must be changed.

1.27 12.2 AGITATION

12.2.1 Shake the film horizontally and vertically, ideally for a few seconds each minute during development. This shall help film develop evenly.

1.28 12.3 STOP BATH OR RINSE

12.3.1 After development is complete, the activity of developer remaining in the emulsion should be neutralized by an acid stop bath or, if this is not possible, by rinsing with vigorous agitation in clear water. Follow the film manufacturer's recommendation of stop bath composition (or length of alternative rinse), time immersed, and life of bath.

1.29 12.4 FIXING

12.4.1 The films must not touch one another in the fixer. Agitate the hangers vertically for about 10s and again at the end of the first minute, to ensure uniform and rapid fixation. Keep them in the fixer until fixation is complete (that is, at least twice the clearing time). Frequent agitation with shorten the time of fixation.

1.30 12.5 WASHING

12.5.1 The washing efficiency is a function of wash water, its temperature, and flow, and the film being washed. The films should be washed in batches without contamination from new film brought over from the fixer. If pressed for capacity, as more films are put in the wash, partially washed film should be moved in the direction of the inlet.

12.5.2 The cascade method of washing uses less water and gives better washing for the same length of time. Divide the wash tank into two sections (may be two tanks). Put the films from the fixer in the outlet section. This completes the wash in fresh water.

1.31 12.6 WETTING AGENT

12.6.1 Dip the film for approximately 30s in a wetting agent. This makes water drain evenly off film which facilitates quick, even drying.

1.32 12.7 DRYING

12.7.1 Drying is a function of (1) film (base and emulsion); (2) processing (hardness of emulsion after washing, use of wetting agent); and (3) drying air (temperature, humidity, flow). Manual drying can vary from still air drying at ambient temperature to as high as 140°F (60°C) with air circulated by a fan. Take precaution to tighten film on hangers, so that it cannot touch in the dryer. Too hot a drying temperature sat low humidity can result in uneven drying and should be avoided.

13. VIEWING

13.1 The radiographs shall be examined in a darkened room on the viewer. The brightness of the viewer should preferably be adjustable so as to allow satisfactory reading of the radiographs.

13.2 Densitometers or step wedge comparison film may be used to density measurement.

14. ACCEPTANCE STANDARDS

Acceptance criteria shall be as per Para. UW – 51 (b) of ASME VIII Div. 1.

Indications revealed by radiography within a weld that exceed the following criteria are unacceptable and therefore are defects.

- any indication characterized as a crack or zone of incomplete fusion or penetration;
- any other elongated indication on the radiograph which has length greater than:
  - 1/4 in. (6 mm) for t up to 3/4 in. (19 mm)
  - 1/3t for t from 3/4 in. (19 mm) to 2 ¼ in. (57 mm)
  - 3/4 in. (19 mm) for t over 2 ¼ in. (57 mm)

Were

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

- **any group of aligned indications that have an aggregate length greater than t in a length of 12t, except**

when the distance between the successive imperfections exceeds 6L where L is the length of the longest imperfection in the group;

- **rounded indications in excess of that specified by the acceptance standards given in Mandatory Appendix 4.**

15. RETEST OF REPAIRS

Repaired areas on the material shall be retested using the same procedure as original test.

16. DOCUMENTATION

1.33 16.1 RADIOGRAPHIC TECHNIQUE INFORMATION

16.1.1 To aid in proper interpretation of radiographs, details of the radiographic examination technique used may accompany each group of radiographs

1.34 16.2 EVALUATION BY MANUFACTURER

16.2.1 Prior to being presented to the inspector for acceptance, the radiographs shall be interpreted by the manufacturer as complying with the referencing code section. The manufacturer shall record the

interpretation of each radiograph and disposition of the material examined on a radiographic interpretation review form accompanying the radiographs.

1.35 16.3 FILM STORAGE

16.3.1 A complete set of films shall be retained and kept on file for a period of 5 (five) year by Vendor. After expiry of retention period the relevant radiographs may be destroyed with prior written approval of QC/QA Manager.

17. REPORTING

A sample report is attached to the next page.

Reference's Code: PR-01-10 Review No.: 04 Review Date: 16.07.2022	**RADIOGRAPHIC EXAMINATION REPORT**	MFS
Form's Code: FR-08-01/53	Review No.: 01	Review Date:16.07.2022

Report No: Date of RT:
Project Name: Page: Of

Client: Area: Ref. Standard Acceptance Criteria:	IQI Type: Sensitivity: Density: S. F. D.: Exposure Technique. Film Type:	Screen: Radiation Source: Activity: (Ci) Voltage (Kv), Current (ma) Exposure Time: (min) Focal Spot Size: (mm)

Item	*Description*	*Weld No.*	*Welder stamp*	*Dia (Inch) Length (m m)*	*Thk.(mm)*	*Film Size*	*Segment (mm)*	*Defect Type & Location*	*Result*			
									RT	RS	RP	Acc

Remarks: Material:	No. Of Films:	Length (Cm):

NDT Agency	*MANUFACTURER*	*PURCHASER*	*TPA*	*LIDCO*
Name: Date : Sign :	Name: Date : Sign :	Name: Date : Sign :	Name: Date : Sign :	Name: Date : Sign :

MFS "مدرک معتبر"

PT PROCEDURE

1. SCOPE

1.1 This procedure provides the method and acceptance standard for visible liquid penetrant examination of weldments. The purpose of executing this operation is to discerning the existing cracks and defects on the weld seams.

2. DEFINITIONS

CLIENT: **National Iranian South Oilfields Company (NISOC)**

PROJECT: **Binak Oilfield Development – General Facilities**

EPD/EPC CONTRACTOR (GC): **Petro Iran Development Company (PEDCO)**

EPC CONTRACTOR: **Joint Venture of: Hirgan Energy – Design & Inspection(D&I) Companies**

VENDOR: **MFS Co.**

3. REFERENC DOCUMENT

- ASME BPVC SEC. V_2017
- ASME BPVC SEC VIII, DIV. 1_2017
- ASNT, SNT-TC-1A (latest edition)
- SPECIFICATION FOR PRESSURE VESSELS (Doc No.: BK-00-GNRAL-000-ME-SP-0001-D03)

4. GENERAL REQUIREMENTS

4.1 Liquid penetrant test is a nondestructive test means of locating and determining the severity of surface discontinuities in materials, which was based upon capillarity. Capillarity or capillary attraction is the action by which the surface of a liquid, where it is in contact with a solid, is elevated or depressed. The materials, processes and procedures used in liquid penetrate testing are designed to facilitate capillarity and to make the results of such action visible and capable for interpretation.

4.2 Sequence of the test procedure, divided into six following main steps:

a) The surface of the specimen is first cleaned and allowed to dry.

b) Penetrant is applied to the test surface and shall permit sufficient time to seep in to opening.

c) The penetrant remaining on the surface is removed without removing the penetrant from opening.

d) Developer is applied to aid in drawing the penetrant back to the surface.

e) The surface of the specimen is visually examined to locate penetrant indications which have formed in the developer coating.

f) When post examination cleaning is required, it should be conducted as soon as practical using a process that does not adversely affect the part.

5. PERSONNEL QUALIFICATION

5.1 Personnel performing the nondestructive examination are qualified in accordance the requirements of SNT-TC-1A (latest edition).

5.2 Only qualified and certified Level II or Level III personnel shall be done all examination and evaluation

6. PRECAUTION FOR PERSONNEL SAFETY

6.1 The liquid penetrant materials should be used in well ventilated areas because they are highly volatile and flammable. The liquids should not be heated above 52 ºC or exposed to open flames or hot surfaces. Empty aerosol cans shall not be thrown into an open fire because of the explosive hazard.

6.2 Care shall be taken to avoid overheating of the pressurized cans. If they must be heated to reach the required operating temperature heating shall be accomplished by using a hot water bath having an immersed thermometer.

7. ESSENTIAL AND NON-ESSENTIAL VARIABLE

Requirement	Essential Variable	Nonessential Variable	Applicable paragraph or clause at this project
Identification of and any change in type or family group of penetrant materials including developers, emulsifiers, etc.	*	–	clause 8.4
Surface preparation (finishing and cleaning, including type of cleaning solvent)	*	–	clause 9
Method of applying penetrant	*	–	clause 10.2
Method of removing excess surface penetrant	*	–	clause 12

Hydrophilic or lipophilic emulsifier concentration and dwell time in dip tanks and agitation time for hydrophilic emulsifiers	*	–	not applicable
Hydrophilic emulsifier concentration in spray applications	*	–	not applicable
Method of applying developer	*	–	clause 14
Minimum and maximum time periods between steps and drying aids	*	–	clause 11
Decrease in penetrant dwell time	*	–	clause 11
Increase in developer dwell time (Interpretation Time)	*	–	clause 14.4
Minimum light intensity	*	–	clause 14.5
Surface temperature outside 40°F to 125°F (5°C to 52°C) or as previously qualified	*	–	clause 10.1
Performance demonstration, when required	*	–	clause 20
Personnel qualification requirements	–	*	clause 5
Post-examination cleaning technique	–	*	clause 16
Materials, shapes, or sizes to be examined and the extent of examination	–	*	clause 17

8. MATERIALS

8.1 Before start of an examination, below items should be checked:

1) The batch no. on tins or aerosols shall be readable.
2) The consumable shall be within the expiry date or "best before" date of above items cannot be met, the corresponding consumables shall not be used.

8.2 The penetrant material shall be able to detect the opening surface discontinuity as per standard requirement.

8.3 When examining austenitic stainless steel, titanium and nickel-based alloys the examination material shall be certified for halogen and sulfur contents shall not exceed 1% by weight.

8.4 The use of different manufacture´s consumable within a specific system is not permitted.

8.5 The materials which shall be used in liquid penetrant test include:

1) Penetrants (Trade mark: magna flux)
2) Solvents or cleaning agents (Trade mark: magna flux)
3) Developers. (Trade mark: magna flux)

8.6 All materials shall be supplied from same manufacturer.

8.7 Intermixing of penetrant material from different families or different manufactures is not permitted.

8.8 The mentioned ingredient must cover either liquid or powder form and are available in pressurized spray cans.

8.9 When examining austenitic or duplex stainless steel, all penetrant materials shall be analyzed individually for chlorine and fluorine content in accordance with SE-165, Annex 4. Alternatively, the material may be decomposed and analyzed in accordance with SD-808 or SE-165, Annex 2 for chlorine and SE-165, Annex 3 for fluorine. The total chlorine and fluorine content shall not exceed 0.1% by weight.

9. SURFACE PREPARATION

9.1 Satisfactory results are usually obtained when the surfaces are in the as-welded, as-rolled, as-cast, or as-forged conditions. Surface preparation by grinding, machining or other methods may be necessary where surface irregularities could mask indications of unacceptable discontinuities. Operations that may peen or close discontinuity openings and compromise the integrity of the examination such as shot, sand or grit blasting are not recommended. When these operations are performed, precautions such as Alkaline or Acid etching shall be performed to ensure reopening of those discontinuities.

9.2 Prior to each liquid penetrate examination, the surface shall be checked and all adjacent weld line areas within 1 in shall be dry and free of all dirt, grease, lint, scale, welding flux and spatter, paint, oil, and other contaminant matter that could obscure surface openings or otherwise interfere with the examination.

9.3 After completing cleaning operation, the surface shall be dried by exerting normal evaporation.

9.4 Typical cleaning agents, which may be used, are detergents, organic solvents, decaling solutions, and paint removers.

9.5 Cleaning methods employed is the important part of the test operation.

10. PENETRATE APPLICATION

10.1 Temperature of penetrant and parts to be inspected shall be maintained between 50° F (10°C) and 125°F (52°C) throughout the examination period. Local heating or cooling shall be permitted provided the part temperature remains in the range of 10 °C to 52 °C during the test.

10.2 When it is not practical to conduct a liquid penetrant examination within the temperature range of 10°C to 52 °C, the examination procedure at the proposed lower or higher temperature range, the test shall be performed in accordance with appendix III of article 6, ASME section V.

10.3 The surface to be tested shall be thoroughly coated with penetrant by spraying, or immersion.

11. PENETRATION TIME

11.1 The surface to be tested shall be kept wet for a minimum of 10 minutes. During this period, if necessary, additional penetrant may be used. Penetration (dwell) time is critical. The minimum and maximum penetration time shall be as required in Table 2 or as qualified by demonstration for specific applications.

Table 2

Material	Form	Type of Discontinuity	Dwell Time

			Penetrant	Developer
Aluminum, magnesium, steel, brass and bronze, titanium and high-temperature alloys	Castings and welds	Cold shuts, porosity, lack of fusion, cracks (all forms)	Min: 5min Max: 2 hrs. so that penetrant shall not be allowed to dry	Min: 7min Max: 1 hr. after as soon as a wet developer coating is dry.
	Wrought materials - extrusions, forgings, plate	Laps, cracks (all forms)	Min: 10min Max: 2 hrs. so that penetrant shall not be allowed to dry	Min: 7min Max: 1 hr. after as soon as a wet developer coating is dry

Note: For temperature from 50 °F to 125 °F. For temperature from 40 °F up to 50 °F, minimum penetrant dwell time shall be 2 times the value listed.

Note: The penetrant shall not be allowed to dry during the entrance time. If drying occurs, the penetrant removed and reapplied.

12. EXCESS PENETRANT REMOVAL

12.1 Excess solvent removable penetrants shall be removed by wiping with a cloth or an absorbent paper. To minimize removal of penetrant from discontinuities; care shall be taken to avoid the use of excess solvent. Flushing the surface with solvent, following the application of the penetrant and prior to developing is prohibited.

13. DRYING AFTER EXCESS PENETRANT REMOVAL

13.1 Drying is necessary prior to applying non-aqueous developer. Parts can be dried by used adequate methods such as blotting with lint free materials, circulating warm air (surface temperature is not raised above 52 °C), normal evaporating, and blowing with compressed air at a not higher than 50 Psi (3.4 kg/cm) on the surface of the parts.

13.2 Drying time shall vary with the size, nature and number of parts under inspection, A minimum 3 minutes of drying time by normal evaporation shall be allowed after the excess penetrant removal and prior to developer application but shall not exceed 5 minutes to avoid excessive drying.

14. DEVELOPING

14.1 The developer shall be applied by spraying as soon as possible after penetrant removal. Insufficient coating thickness may not draw the penetrant out of discontinuities; conversely, excessive coating thickness may mask indication.

14.2 non-aqueous developers shall be applied only to dry surfaces by spraying. Prior to applying the developers. It is necessary that they continually agitate in order to prevent settling of solid particles dispersed in the liquid.

14.3 Developing time for final interpretation beings immediately after the application of a dry developer or as soon as a wet developer coating is dry.

14.4 If the surface to be examined is so large as to preclude complete examination within the prescribed time, only portions of the test shall be examined at one time.

14.5 Developing time for final interpretation beings immediately after the application of a dry developer as soon as a wet developer coating is dry. The minimum and maximum developing time shall be as required by table 2.

14.6 If the surface to be examined is so large as to preclude complete examination within the prescribed time, only portions of the test shall be examined at one time.

14.7 A minimum light intensity of 100 fc (1076 Lux) is required on the surface to ensure adequate sensitivity during the examination and evaluation of indications.

15. INTERPRETATION

15.1 Final interpretation shall be made not less than 10 min nor more than 60 min after the requirements of (Developing time for final interpretation begins immediately after the application of a dry developer or as soon as a wet developer coating is dry) are satisfied, unless otherwise qualified under(When it is not practical to conduct a liquid penetrant examination within the temperature range of 40°F to 125°F (5°C to 52°C), the examination procedure at the proposed lower or higher temperature range requires qualification of the penetrant materials and processing in accordance with Mandatory Appendix III of this Article). 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.

15.2 Any relevant linear indication greater than 1/16 in. (1.6 mm) shall be repaired or removed.

15.3 A linear indication is one having a length greater than three times the width.

15.4 A rounded indication is one of circular or elliptical shape with a length equal to or less than three times its width.

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

15.6 All indications shall be evaluated against the acceptance standards.

15.7 Discontinuities at the surface shall be indicated by bleed-out the penetrate; however, localized surface irregularities due to machining marks or other surface conditions may produce false indications.

15.8 Linear indications are evaluated as crater crack or star crack and exceed 5/32 in (4 mm) in length.

15.9 Linear indications are evaluated as Incomplete Fusion and exceed1in (25 mm) in total length in a continuous 12 in (300 mm) length of the weld or 8% of the weld length.

15.10 Individual or scattered porosity shall be unacceptable when any of the following condition exists:

a) The size of an individual pore exceeds 1/8 in (3 mm)

b) The size of an individual pore exceeds 25% of the thinner of the nominal wall thickness joined

15.11 Cluster porosity in the finish pass shall be considered a defect Should any of the following conditions exist:

a) The aggregate length of cluster porosity in any continuous 12 in (300 mm) length of weld exceeds ½ in (13 mm).

b) The diameter of the cluster Porosity exceeds ½ in (13 mm).

16. POST-EXAMINATION CLEANING

16.1 When post examination cleaning is required, it should be conducted as soon as practical after evaluation and documentation using a process that does not adversely affect the part.

17. REPAIR AND RE-EXAMINATION

17.1 Where defects are unacceptable, the location shall be removed and weld repair shall be done.

17.2 Re-examination of the repaired weld seam shall be done accordingly. Re-examined by the liquid penetrant method and by all other methods of examination that were originally required for the affected area, except that, when the depth of repair is less than the radiographic.

18. ACCEPTANCE CRITERIA

18.1 Acceptance Standards

- ASME Sec. VIII Div. 1 Appendix 8
- These acceptance standards shall apply unless other more restrictive standards are specified for specific materials or applications within this Division.

18.2 All surfaces to be examined shall be free of

1) relevant linear indications;
2) relevant rounded indications greater than 3/16 in (5 mm);
3) four or more relevant rounded indications in a line separated by 1/16 in (1.5 mm) or less, edge to edge.

19. PERFORMANCE DEMONSTRATION

19.1 The performance demonstration establishes the ability of a specific examination system to achieve a satisfactory probability of detection (POD), by application of the examination system on flawed test specimens. Performance demonstration, when required by the Applicable Codes and Standards, shall be documented. (The performance demonstration is not required according to Applicable Codes and Standards).

20. RECORDS

20.1 Examination report shall be including the information below, as a minimum.

1) Parts identification
2) Material thickness

3) Applied procedure number
4) Lighting equipment
5) Examination condition.
6) Type of penetrant materials, test date
7) Results
8) Name and signature of inspector
9) Examination personnel

21. APPENDIX

21.1 Sample of PT report are attached on the next page.

کد سند مرجع: PR-08-01 شماره بازنگری: ۰٤ تاریخ بازنگری: ۱۴۰۱/۰۴/۲۵	تست غیر مخرب گزارش تست نفوذ رنگ	MFS
تاریخ بازنگری: ۱٤۰۱/۰٤/۲۵	شماره بازنگری: ۰۳	کد فرم: FR-08-01/11

DYE PENETRANT TEST REPORT

CLIENT:	PROJECT:	DATE :
EQUIPMENT NAME :	Material :	
DWG NO. :	Report No.:	Sheet of

EXAMINATION TYPE/METHOD:

☐ POST EMULSIFYING ☐ WATER WASHABLE ☐ SOLVENT REMOVABLE Color, Florsent ☐

ITEM	DISCRIPTION :	THICKNESS (MM)	LOCATION	P.T. Percent	EXAMINATION TIME	WELDER STAMP	RESULT						REMARK
							Accept			Repair			
							1	2	3	1	2	3	

MANUFACTURER:	PURCHASER:	TPA:	LIDCO:

MT PROCEDURE

1. SCOPE

1.1 This document describes the minimum requirements for magnetic particle examination procedure of welds.

2. DEFINITIONS

CLIENT: **National Iranian South Oilfields Company (NISOC)**

PROJECT: **Binak Oilfield Development – General Facilities**

EPD/EPC CONTRACTOR (GC): **Petro Iran Development Company (PEDCO)**

EPC CONTRACTOR: **Joint Venture of: Hirgan Energy – Design & Inspection(D&I) Companies**

VENDOR: **MFS Co.**

3. REFERENC DOCUMENT

- ASME BPVC SEC. V_2017
- ASME BPVC SEC VIII, DIV. 1_2017
- ASNT, SNT-TC-1A (latest edition)
- SPECIFICATION FOR PRESSURE VESSELS (Doc No.: BK-00-GNRAL-000-ME-SP-0001-D03)

4. PERSONNEL QUALIFICATION

4.1. Personnel performing the nondestructive examination are qualified in accordance the requirements of SNT-TC-1A (latest edition).

4.2. Only qualified and certified Level II or Level III personnel shall do all examination and evaluation.

5. GENERAL REQUIREMENTS

5.1 Magnetizing equipment:

5.2 Magnetic particle examination shall be performed by the electro-magnet method.

a) The prods method shall not be used because this equipment could produce arc strikes on the pieces to be tested.

b) When magnetic particle examination is required, the DC yoke method shall be used prior to PWHT while the AC yoke method shall be used after PWHT.

5.2 Magnetic Particles (Wet method):

5.2.1 The Visible (Color Contrast) of the particles used shall provide adequate contrast with the surface being examined.

5.3 The shape and size of all magnetic particles, either wet or dry, suspension vehicle and concentration shall be in accordance with SE-709.The concentration of wet magnetic particles in the liquid vehicle shall be from 1.2 to 2.4 ml per 100 ml sample. The temperature of the wet particle suspension and surface of the part shall not exceed 57°C.

5.4 Particle applicators:

5.4.1 Wet magnetic particles are designed to be suspended in a vehicle such as water or light petroleum distillate at a given concentration for application to the test surface by flowing, spraying. The exact brand material for example: Magnaflux or Ely or Ambersil shall be used.

5.5 Field indicator:

5.5.1 The Pie-shaped magnetic particle field indicator shall be used to determine the adequacy of the magnetic field strength. When a clearly defined line of magnetic particles is not formed, or is not formed in the desired direction, the magnetizing technique shall be changed or adjusted.

5.6 Surface preparation:

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

b) Prior to magnetic particle examination, the surface to be examined and all adjacent areas within at least 25mm. shall be dry and free of all dirt, grease, lint, scale, welding flux and spatter, oil, any existing coating or paint layer on the component will have an adverse effect on defect detection if it is greater than 50 µm thick or other extraneous matter that could interfere with the examination.

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

d) Surface Temperature for Dry Method Max. 600° F (316 °C) and Surface Temperature for Wet Method Max. 135° F (57 °C). If the temperature of the examination surface is outside of this value, the inspection will stop until the surface temperature reaches the specified temperature.

e) When using visible color particles, the surface to be examined shall be temporarily coated with a thin uniform coat of white contrast paint.

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

5.7 Examination coverage:

5.7.1 Examination shall be conducted with sufficient overlap (> 15%) to ensure 100% coverage at the established test sensitivity. Examination of weld seams shall include at least ½ in (13 mm) of base material on each edge of weld where possible.

5.8 Calibration of equipment:

5.8.1 Frequency: Each piece of magnetizing equipment with an ammeter shall be calibrated at least once a year, or whenever the equipment has been subjected to major electric repair, periodic overhaul, or damage. If equipment has not been in use for a year or more, calibration shall be done prior to first use. In either case by every time of application, the equipment shall verify against procedure mention on Article 5. Yoke that fails to lift calibration block shall not be used for inspection All Calibration data shall be recorded.

5.9 Visible light intensity for examination:

5.9.1 The intensity of the visible light at the surface of the part/work piece undergoing examination should be a minimum of 100-foot candles (1076 Lux).

5.9.2 Essential and non-essential variables:

Requirement	**Essential Variable**	**Nonessential Variable**	**Applicable paragraph or clause at this procedure**
Magnetizing technique	*	–	clause 6.2
Surface preparation	*	–	clause 5.6
Magnetic particles (fluorescent/visible, color, particle size, wet/dry).	*	–	clause 5.2
Method of particle application	*	–	clause 5.4
Method of excess particle removal	*	–	clause 6.4
Minimum light intensity	*	–	clause 5.9
Nonmagnetic surface contrast enhancement, when utilized	*	–	clause 5.6 (f)
Examination part surface temperature outside of the temperature range recommended by the manufacturer of the particles or as previously qualified	*	–	clause 5.6 (d)
Shape or size of the examination object	–	*	clause 12
Demagnetizing technique	–	*	clause 10
Post-examination cleaning technique	–	*	clause 11
Personnel qualification requirements	–	*	Clause 4

Existing coatings, greater than the thickness demonstrated	*	–	clause 5.6 (b)
Temperature (within those specified by manufacturer or as previously qualified)	–	*	clause 5.6 (d)

6. 0YOKE METHOD

6.1 Examination medium: magnetic particles described in Para. 5.2 shall be used.

6.2 Magnetizing power

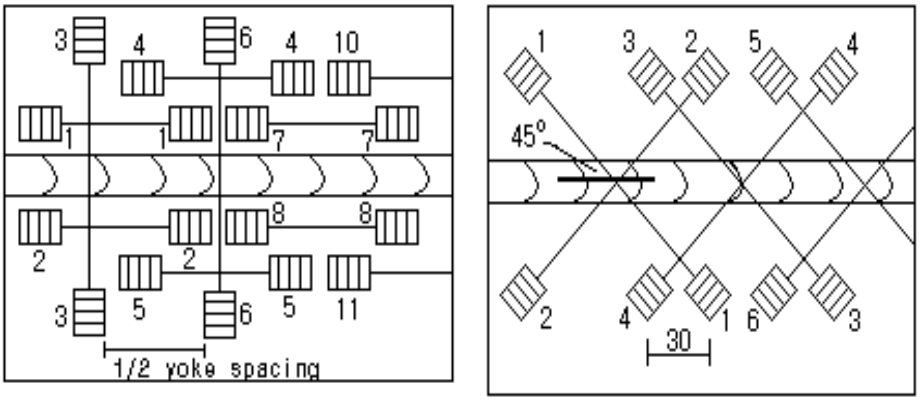
a) The magnetizing power of yokes shall be verified prior to use each day the yoke is used. The magnetizing power of yokes shall be verified whenever the yoke has been damaged or repaired.

b) Each alternating current electromagnetic yoke shall have a lifting power of at least 10 lb (4.5 kg) at the maximum pole spacing, with contact similar to what will be used during the examination.

c) Each direct current or permanent magnetic yoke shall have a lifting power of at least 40 lb (18 kg) at the maximum pole spacing, with contact similar to what will be used during the examination.

6.3 Direction of magnetization: At least two separate examinations shall be carried out on each area. The second examination shall be with a perpendicular magnetic flux to that used in the first examination. A different means of magnetizing may be employed for the second examination of the area.

6.4 Procedure: after the means of magnetizing have been brought into proper relationship with the surface to be examined, the magnetic particles shall be applied. Any excess shall be removed with a gentle air stream. The air stream should not disturb or remove lightly held particle patterns. In order to recognize the broad, fuzzy lightly held patterns produced by subsurface discontinuities, it is essential to observe carefully the formation of indication while the particles are being applied, and also while any excess is being remove. Proper lighting shall facilitate observations of these patterns. Indications of discontinuities are noted. The current is then turned off and yokes repositioned for the second examination of the area. Examinations shall be conducted with sufficient overlap to assure 100 percent coverage at the established test sensitivity as Fig. (a) or (b) below:



Yoke Movement Pattern

7. EVALUATION OF INDICATIONS

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

a) A linear indication is one having a length greater than three times the width.

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

c) Any questionable or doubtful indications shall be reexamined to determine whether or not they are relevant but when after re-examination the questionable or doubtful indication is remains, this shall be judged as relevant.

d) All indications shall be evaluated against the acceptance standards.

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

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

g) An indication of an imperfection may be larger than the imperfection that causes it; however, the size of the indication is the basis for acceptance evaluation.

8. ACCEPTANCE CRITERIA

8.1 The following relevant indications are unacceptable:

a) Any cracks or linear indications.

b) Rounded indications with dimensions greater than 3/16 in (5 mm)

c) Four or more rounded indications in a line separated by 1/16 in (1.5 mm) or less edge to edge.

9. REPAIR & RE-EXAMINATION

9.1 Where defects are unacceptable, the location shall be removed and weld repair done.

9.2 Re-examination of the repaired weld seam shall be done accordingly.

9.3 After repairs have been made, the repaired area shall be blended into the surrounding surface so as to avoid sharp notches, crevices, or corners and reexamined by the magnetic particle method and by all other methods of examination that were originally required for the affected area.

10. DEMAGNETIZATION

10.1 When residual magnetism in the part could interfere with subsequent processing or usage, the part shall be demagnetized any time after completion of the examination. Alternating current yokes may be used for local demagnetization by placing the poles on the surface, moving them around the area, and slowly withdrawing the yoke while it is still energized.

11. POST EXAMINATION CLEANING

11.1 When post examination cleaning is required after the procedure, it should be conducted as soon as practical using a process that does not adversely affect the part.

11.2 Extent of post-test cleaning should be specified by purchaser's representative or TPI.

12. SHAPE OR SIZE OF THE EXAMINATION OBJECT

Material shape	Thickness (mm)	Material alloy
weld metal (groove)	10~82	C.S (P.no 1)

13. RECORDS

13.1 Examination report shall be including the below information, as a minimum.

1) Procedure identification and revision;
2) Magnetic particle equipment and type of current;
3) Magnetic particles (visible or fluorescent, wet or dry);
4) Material and thickness;
5) Date of examination;
6) Surface condition;
7) Magnetization Technic.
8) Map or record of indications shall also be reported.

14. APPENDIX

14.1 Sample of MT report are attached on the next page.

کد سند مرجع: PR-08-01 شماره بازنگری: ۰٤ تاریخ بازنگری: ۱۴۰۱/۰۴/۲۵	گزارش تست مغناطیسی MAGNETIC TEST REPORT	MFS
تاریخ بازنگری: ۱۳۹۷/۰۶/۰۵	شماره بازنگری: ۰۲	کد فرم: FR-08-01/14

ITEM NAME & NO.:	PROJECT:		PAGE : OF
MATERIAL:	CODE/STANDARD: ASME SEC V	MAGNETIZING CURRENT:	REPORT NO:

SURFACE CONDITIO: ☐ AS WELDED ☐ AS FORGED ☐ AS CASTED ☐ AS MACHINED ☐ AS GROUND ☐ OTHER

WELDING PROGRESS: ☐SMAW ☐ GTAW ☐GMAW ☐FCAW ☐SAW ☐OTHER | GROOVE TYPE: ☐V ☐U ☐X ☐K ☐OTHER

EQUIPMENT MAKER&MODEL:	MAGNETIC PARTICLE: MAKER&MODEL: MAGNA FLUX / WHITE CONTRAST ☐COLOR/FLURSE

REFERENCE BLOCK:

PROCEDURE NO.: | EXAMINATION TIME: AFTER PWHT

NO	DATE	LINE IDENTIFICATION	THK (MM)	OD	RESULT		REMARKS
					ACCEPT	REPAIR	

ATTACHMENT : YES☐ NO ☐ EXAMINED BY:	AUTHORITY: NAME: SIGNATURE: DATE:	SKETCH :
INTERPRETED BY	MANUFACTURER: NAME: SIGNATURE: DATE:	
APPROVED BY	PURCHASER: NAME: SIGNATURE: DATE: TPA: NAME: SIGNATURE: DATE:	
CLIENT	LIDCO: NAME: SIGNATURE: DATE:	

MFS "مدرک معتبر"

PHASED ARRY AND TOFD

1. SCOPE

This Procedure defines the use of the Time-of-Flight Diffraction (TOFD) & Phased Array Ultrasonic Inspection (PAUT) technique for examination of welds in storage tank, circumference welds (CW) and Longitudinal Weld (LW).

This procedure is designed to demonstrate the Phased Array System as a qualified UT system that meets all the requirements of ASME Code sec V-Article 4. For the weld width of weld shall be examined with additional 25 mm of both side of the weld containing heat affected zone (HAZ) to cover the areas for these examinations in accordance with ASME SEC VIII D2 Para 7.5.5.1.

2. DEFINITIONS

CLIENT: **National Iranian South Oilfields Company (NISOC)**

PROJECT: **Binak Oilfield Development – General Facilities**

EPD/EPC CONTRACTOR (GC): **Petro Iran Development Company (PEDCO)**

EPC CONTRACTOR: **Joint Venture of: Hirgan Energy – Design & Inspection(D&I) Companies**

VENDOR: **MFS Co.**

3. REFERENC DOCUMENT

- **ASME BPVC Sec. V_2017**
- **ASME BPVC, Sec. VIII (Div. 1) _2017**

Mandatory Appendis V & VIII

- **ASNT Recommended Practice No. ASNT-TC-1 A for NDT Personnel Qualification and Certification**
- ASTM E2491 Ed 2018 Standard Guide for Evaluating Performance Characteristics of Phased-Array Ultrasonic Testing Instruments and Systems
- ASTM E-2373-09- Standard Practice for Use of the Ultrasonic Time of Flight Diffraction (TOFD) Technique
- **ISO, 13588:2019 -Non-destructive testing of welds Ultrasonic testing**
- Acceptance Criteria (Refer: ASME CODE CASE 2235)
- SPECIFICATION FOR PRESSURE VESSELS (Doc No.: BK-00-GNRAL-000-ME-SP-0001-D03)

4. PERSONNEL QUALIFICATION

The written procedure and test instruction shall be approved by Level III personnel in Ultrasonic testing that has the minimum certification in TOFD & PAUT Level II. Analysis of data and acceptance of the report shall be performed by personnel certified as a minimum to level II in accordance with ASNT-TC-1A – 2011 Ed./ISO 9712 in TOFD & PAUT As alternative other qualification standards as LII CSWIP or PCN is acceptable. Equipment set-up, shall be performed by personnel certified as a minimum to level 2 in TOFD & PAUT in accordance with ASNT-TC-1A – 2011 Ed./ ISO 9712 Data acquisition, data storage and weld scanning may be performed by personnel certified as a minimum level II in ultrasonic testing in accordance with ASNT-TC-1A – 2011 Ed./ISO 9712 provided that they have enough knowledge and training in TOFD & PAUT system scanning.

Personnel who acquire and analyze TOFD & PAUT data shall be trained using the equipment indicated in this procedure and be participated in the qualification of this procedure

5. TIME OF TEST APPLICATION

TOFD & PAUT examination will be applied 24 hours after finishing the weld. If the test is performing after the PWHT, it has to be indicated in the report of exam.

6. PREPARATION OF EXAMINATION

6.1 Surface preparation

The parent metal on each side of the weld shall be free of weld spatter, surface irregularities or foreign materials that might interfere with the examination over a distance of 300 mm on Both side of the weld axis.

Note: Where the weld surface interferes with the examination, the weld will be prepared as needed to permit examination. This applies also when the cap width or its irregularities affect the probe coupling. When the cap is ground, the transition with the surface of the parent metal shall be smooth. 20 cm from the beginning of the all-Longitudinal Welds reinforcement shall be smoothed on one or both sides of the circumference welds for special NDT (Means connections LW to CW or similar) as such a way that are not obstacles in the direction of the probs' movement.

6.2 Temperature

The difference temperature of the surface of the part and the calibration block shall not exceed 14 ° C.

7. EQUIPMENT

7.1 Equipment

The ultrasonic equipment is a digital device with a sample rate compatible with the frequencies of the used probes and at least 8 times the nominal frequency probes used, and at minimum equal to 100 MHZ.

Real time visualization and storage of A-scan and D-scan Signal digitization up or equal at 8 bits, Gain range up or equal to 50 dB Encoder input, Tools for calibration and linearization, Hyperbolic cursors,

Filters and average function (at least 16 A scan)

TOFD equipment fulfilling the above conditions is operated with the automatic or semi-automatic system and with multi-channel system. This TOFD equipment is used for making the more convenient reports by recording raw data and flaw sizing.

The detailed information on instrument manufacturer, model and software are as below.

1) Manufacturer (Brand): Sonatest

2) Model: Veo+

3) Maximum digitizing frequency: up to 100 MHz

4) Software for collection and analysis: UT Studio+

7.2 Probes

TOFD **mono crystal probes (Phoenix ISL 5M)**

PAUT **Array 1D (Sonatest X3A-5M64E-0.6x10)**

7.3 Wedges

TOFD **Angular (Phoenix ISL 45, 60, 70)**

PAUT **Angular (Sonatest X3AW-N55S)**

7.4 Scanning device

A guiding mechanism shall be used, such that the probe movement with respect to the reference line is within ± 10% of the probe center spacing. It has to be demonstrated that the scanner is able to follow marked lines on the adjacent of the weld, helped by manual means, if necessary, with accuracy of 5 mm.

The automatic or Semi-Automatic TOFD & PAUT scanning system has a single-axis coordinate scanner with multi-channel arms. The scanner can be used for circumferential weld inspection, including dissimilar thickness joints, as well as longitudinal weld inspection. Compatible scan surface could be flat, cylindrical or even spherical.

7.5 Coupland

Water or Glycerin may be used as couplant. The same Couplant to be used during the calibration shall be used for examination.

8. PRE-SCANNING REQUIREMENTS

8.1 Information requirements

Full and accurate details of the item to be inspected shall be obtained prior to the development of a scanning technique. These shall include as minimum:

-Actual component wall thickness

-Material type(s)

-Component geometry

-Surface temperature and condition

-Assembly geometry

-Access limitations if any (approx. 1m of room is needed in all directions around the item under test for optimum testing)

-Any other relevant factors which may inhibit or prevent inspection

8.2 Documented examination strategy or scan plan

A scan plan shall be provided per Client Job Number. The scan plan shall be used to sketch the propagation of the beams and supply the operator with an image of the chosen settings. The settings in the scan plan are to aid the operator to determine the examination strategy, and to list the required number of scans which are necessary to guarantee sufficient coverage for the inspection. All settings from the scan plans shall act as a starting point, from which the operator will determine the actual inspection settings. The actual inspection settings shall be determined on the reference block.

The reference blocks are presented in Appendix I.

9. EQUIPMENT CHECKS/SETTINGS

9.1 Scan plan and set-up validation

A set-up is defined by the probe offset, probe frequency, active aperture, and applied beam angles. The number and configuration of set-ups required for flaw detection purposes will depend on

geometry of, and access to the item under test. In order to satisfactorily cover the inspection volume of interest, more than one set-up may be required.

The initial set-ups shall be based upon experience, modelling, or other data and described in a scan plan. The initial set-ups shall be validated at the start of an inspection on a reference block containing artificial defects.

If during the scans on the reference blocks changes to the number of set-ups or the set-up parameters were required during the validation, these equipment parameters shall be used as reference parameters for the inspection and for the client validation.

The Inspection shall only start if the Client validation has been completed successfully

9.2 System Verification

The calibration standard shall be used daily:

-Before beginning weld inspections

-At end of each series examination

-At the conclusion of the shift

9.2.1 Array functionality check/Element check

A Data file shall be collected using the built-in element check function. The probe used shall be replaced if any of the following occurs.

-adjacent elements are "dead "

-More than 10 % of the array is "dead "

9.2.2 Velocity calibration

Velocity calibration shall be done as first step of phased array calibration by V1(IIW) or V2 calibration block.

9.2.3 Wedge delay Calibration

All individual beams used in the examination shall be calibrated to provide measurement of distance and amplitude correction over the sound path employed in the examination.

9.2.4 Angle Corrected Gain

each beam and focal point generated by the phased array probe shall be bring the signals of defects of the same size and type from all angles to the same amplitude. The method of direct adjustment of interest when measuring on a IIW block with a radius of 100 mm, the recorded range for each angle is modified by the device to show 80% full screen, FSH

9.2.5 TCG set-up

Time Corrected Gain (TCG) shall be done by Side drilled Holes of TCG calibration block in appendix I, to compensate the ultrasonic attenuation for all individual beams in deference depth in both S-scan or E-Scan. Amplitude height of Notch and SDH in different depth for all individual beams should be equal of 80% FSH. The complete coverage of the weld and the HAZ was an important aspect in developing the scan plans. The scan plan was to use the S-scans for thicknesses up to 25 mm & multiple linear scans with S-scans be utilized for components greater than 1 in. (25 mm) thick to optimize coverage to fully examine the weld and the HAZ. An unfocused sound beam will used to develop the approach.

9.2.6 Scan sensitivity

The inspection sensitivity shall be set so that the reference reflector shall be at least 80 % of screen height, after that minimum 6 dB shall be added to set inspection sensitivity during the examination.

9.2.7 Encoder Calibration

Encoder calibration shall be performed at the start of each working day and after exchange of the encoder. The encoder shall be calibrated over a minimum 500mm length of the item under test. The

positional feedback from the encoder shall not differ more than +/- 1% from the actual distance moved.

9.3 Calibration/reference blocks

Appendix I is the sketch of Calibration/reference blocks

9.4 Recalibration

The system shall be recalibrated in the following circumstances.

-Change of critical system variable, i.e. sweep angles, gates, Range etc.
-Change of Search unit or wedge,
-Change of cable length
-Change of equipment
-Change of Personnel
-Change of Couplant
-Change of Power supply (i.e. mains or battery operation)
-If any point on the T.C.G has shifted more than 3 dB from initial settings.

10. SCANNING TECHNIQUE

The data shall be collected by moving the Phased Array and TOFD probes in both side of the weld at uniform speed parallel to the weld, as described in the applicable scan plan.
The inspection shall be carried out as a semi-mechanized inspection with using Weld scanner system, which will guarantee that the sound beam is always, aimed perpendicular to the weld fusion faces.
The collected data shall be presented in A, S, D, and C-scan format.
Each scan shall be performed by collecting full set of data. Scans shall be collected with lengths that allow best manipulation of scanning device and where multiply scans are required a minimum overlap of 25 mm.

11. EVALUATION AND ACCEPTANCE CRITERIA

11.1 Evaluation

11.1.1 Interpretation and analysis

Interpretation and analysis of images is generally performed as follows:
a) Assessing the quality of the images
b) Identification of relevant indications and discrimination of non-relevant indications from the weld geometry
c) Classification of remaining indications in terms of:
- embedded (point-like, elongated with a measurable height or without a measurable height)
- Surface breaking
- Uncategorized
d) Determination of location and size (position, length and through-wall extent)
e) for amplitude-based techniques, the location, Amplitude, and extent of all reflectors that produce a response Greater than 20% of the reference level shall be

Investigated.

f) For no amplitude-based techniques, the location and extent of all images that have an indicated length Greater than the limits in (-1), (-2), or (-3) below, as applicable, shall be investigated.

(-1) For welds in material equal to or less than 1 ½ in. (38 mm) thick at the weld, images with indicated Lengths greater than 0.150 in. (3.8 mm) shall be Investigated.

(-2) For welds in material greater than 1 ½ in. (38 mm) thick but less than 4 in. (100 mm) thick at the weld, images with indicated lengths greater than 0.200 in. (5 mm) shall be investigated.

(-3) For welds in material greater than 4 in. (100 mm) thick at the weld, images with indicated lengths Greater than 0.05t or 0.75 in. (19 mm), whichever is smaller, shall be investigated (t = nominal material thickness Adjacent to the weld).

g) Recording. A-scan data shall be recorded for the area of interest in an unprocessed form with no thresholding, at a minimum digitization rate of five times the examination frequency, and recording increments of a maximum of

(a) 0.04 in. (1 mm) for material < 3 in. (75 mm) thick

(b) 0.08 in. (2 mm) for material ≥ 3 in. (75 mm) thick

An examination has to be carried out such that satisfactory images are generated, which can be evaluated with confidence. Unsatisfactory images may contain:

- Coupling losses (drop in, or total loss of amplitude)
- Data acquisition errors (e.g., excessive missing or displaced scan lines)

White lines appear on the image. Scanning speed shall be such that data drop-out is less than 2 data lines/in. (25 mm) of the linear scan length and that there are no adjacent data line skips.

- Inappropriate sensitivity setting (gain too low or too high)
- Inappropriate time-base setting (incorrect time-window)
- Encoder error

Any unsatisfactory images will require new data acquisition (rescan). For the last point, a new acquisition will be required when possible.

11.1.2 Classification and evaluation of indications

Flaws shall be evaluated for acceptance using the applicable criteria of Table 1 and 2 with the following additional requirements. Unacceptable flaws shall be repaired and the repaired welds shall be re-evaluated for acceptance.

11.1.2.1 Classification

a) Surface Flaws (Figure 1) - Flaws identified as surface flaws during the examination may or may not be surface connected. Therefore, unless the data analysis confirms that the flaw is not surface connected, it shall be considered surface connected or a flaw open to the surface, and is unacceptable unless surface examination (MT or PT) is performed. If the flaw is surface connected, the requirements above still apply.

However, in no case shall the flaw exceed the acceptance criteria in this Division for the material employed.

b) Multiple Flaws

1) Discontinuous flaws shall be considered a singular planar flaw if the distance between adjacent flaws is equal to or less than the dimension S as shown in Figure 2

2) Discontinuous flaws that are oriented primarily in parallel planes shall be considered a singular planar flaw if the distance between the adjacent planes is equal to or less than 13 mm (/2 in.) (see Figure 3).

3) Discontinuous flaws that are planar and nonaligned in the through-wall thickness direction of the

component shall be considered a singular planar flaw if the distance between adjacent flaws is equal to or less than S as shown in Figure 5.

4) Discontinuous flaws that are planar in the through-wall direction within two parallel planes 13 mm (2 in.) apart (i.e., normal to the pressure-retaining surface of the component) are unacceptable if the additive flaw depth dimension of the flaws exceeds those shown in Figure 4.

11.2 Presentation of results

Phased array and TOFD examination results can be presented in A, S, C, D and TOFD scan views each separately or a combination, providing views of an indication from every desired angle. All Phased array and TOFD examination data shall be saved in a suitable format, so that it can be opened with the software associated with the equipment used UT studio+ software. All data backups shall include details of the type and version of this software.

11.3 Acceptance criteria

All flaws observed will be evaluated per Table 1 code case 2235 for 1/2 in. (13 mm) To Less than 1 in. (25 mm) Thick Weld & Table 2 code case 2235 for 1 in. (25 mm) To 12 in. (300 mm) Thick Weld

Excel calculators may also be used for acceptance criteria calculation purposes.

Table 1
Flaw Acceptance Criteria for ½ in. (13 mm) To Less than 1 in. (25 mm) Thick Weld

	a/t	ℓ
Surface flaw	≤0.087	≤0.25 in. (6.4 mm)
Subsurface flaw	≤0.143	≤0.25 in. (6.4 mm)

GENERAL NOTES:

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

(b) A subsurface indication shall be considered as a surface flaw if the separation (S in Figure 1) of the indication from the nearest surface of the component is equal to or less than half the through dimension ($2d$ in Figure 1, sketch [b]) of the subsurface indication.

Table 2
Flaw Acceptance Criteria for 1 in. (25 mm) To 12 in. (300 mm) Thick Weld

	1 in. (25 mm) ≤ t ≤ 2½ in. (64 mm) [Note (1)]		4 in. (100 mm) ≤ t ≤ 12 in. (300 mm) [Note (1)]	
Aspect Ratio, a/ℓ	Surface Flaw, a/t	Subsurface Flaw, a/t	Surface Flaw, a/t	Subsurface Flaw, a/t
0.00	0.031	0.034	0.019	0.020
0.05	0.033	0.038	0.020	0.022
0.10	0.036	0.043	0.022	0.025
0.15	0.041	0.054	0.025	0.029
0.20	0.047	0.066	0.028	0.034
0.25	0.055	0.078	0.033	0.040
0.30	0.064	0.090	0.038	0.047
0.35	0.074	0.103	0.044	0.054
0.40	0.083	0.116	0.050	0.061
0.45	0.085	0.129	0.051	0.069
0.50	0.087	0.143	0.052	0.076

GENERAL NOTES:

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

(b) A subsurface indication shall be considered as a surface flaw if separation (S in Figure 1) of the indication from the nearest surface of the component is equal to or less than half the through thickness dimension ($2d$ in Figure 1, sketch [b]) of the subsurface indication.

(c) If the acceptance criteria in this table results in a flaw length, ℓ, less than 0.25 in. (6.4 mm), a value of 0.25 in. (6.4 mm) may be used.

NOTE:

(1) For intermediate flaw aspect ratio a/ℓ and thickness t (2½ in. [64 mm] < t < 4 in. [100 mm]) linear interpolation is permissible.

Category defect:

Flaws shall be categorized as being surface or subsurface based on their separation distance from the nearest component surface.

(a) If the space is equal to or less than one-half the height of the flaw, then the flaw shall be categorized as a surface flaw

(b) If the space is greater than one-half the height of the flaw, then the flaw shall be categorized as a subsurface flaw `

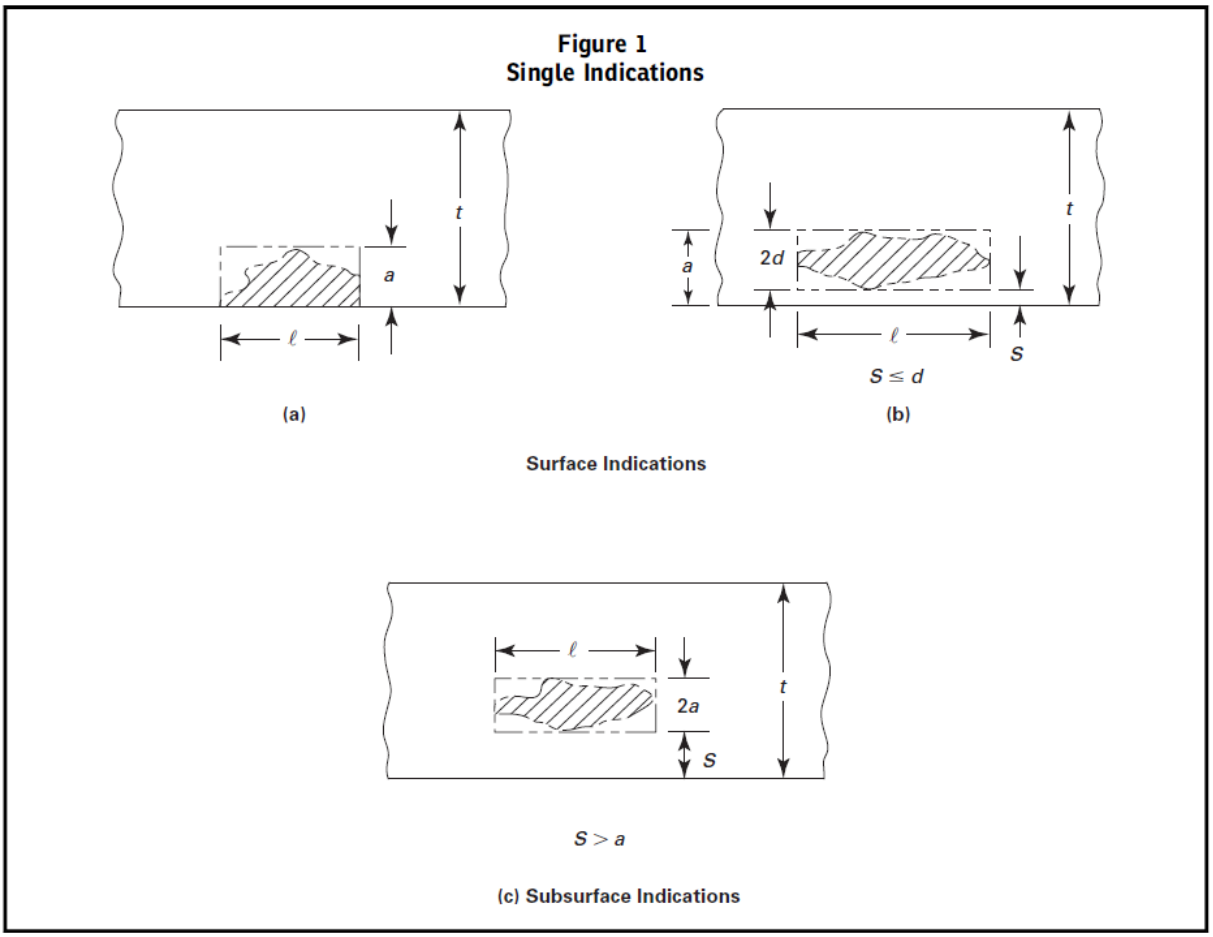
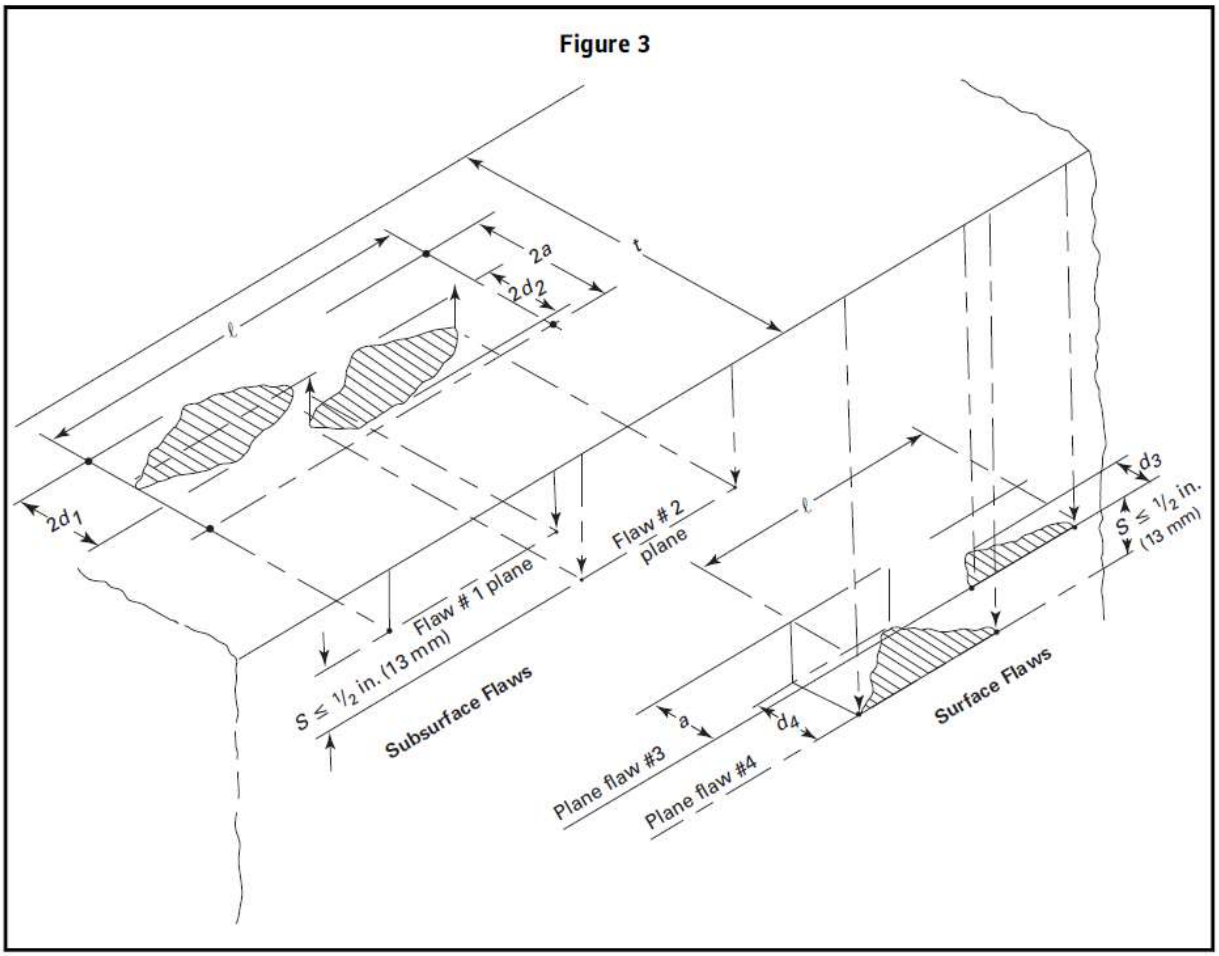


Figure 1: Single Indications

Figure 3


2a
2d2
t
ℓ
2d1
Flaw # 1 plane
Flaw # 2 plane
S ≤ 1/2 in. (13 mm)
Subsurface Flaws
ℓ
d3
S ≤ 1/2 in. (13 mm)
a
d4
Plane flaw #3
Plane flaw #4
Surface Flaws

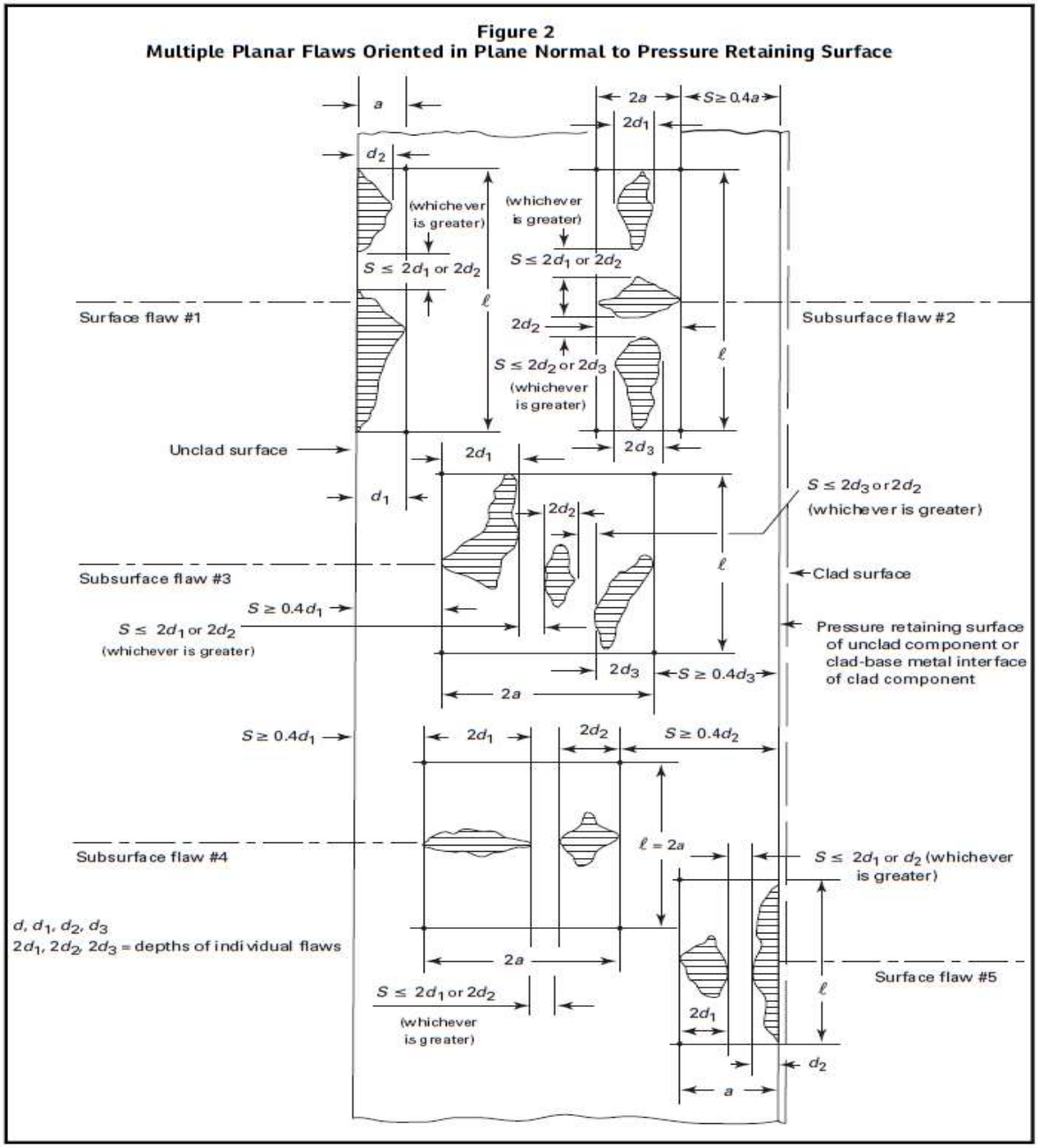


Figure 2: Multiple planar flaws oriented in plane normal to pressure retaining surface

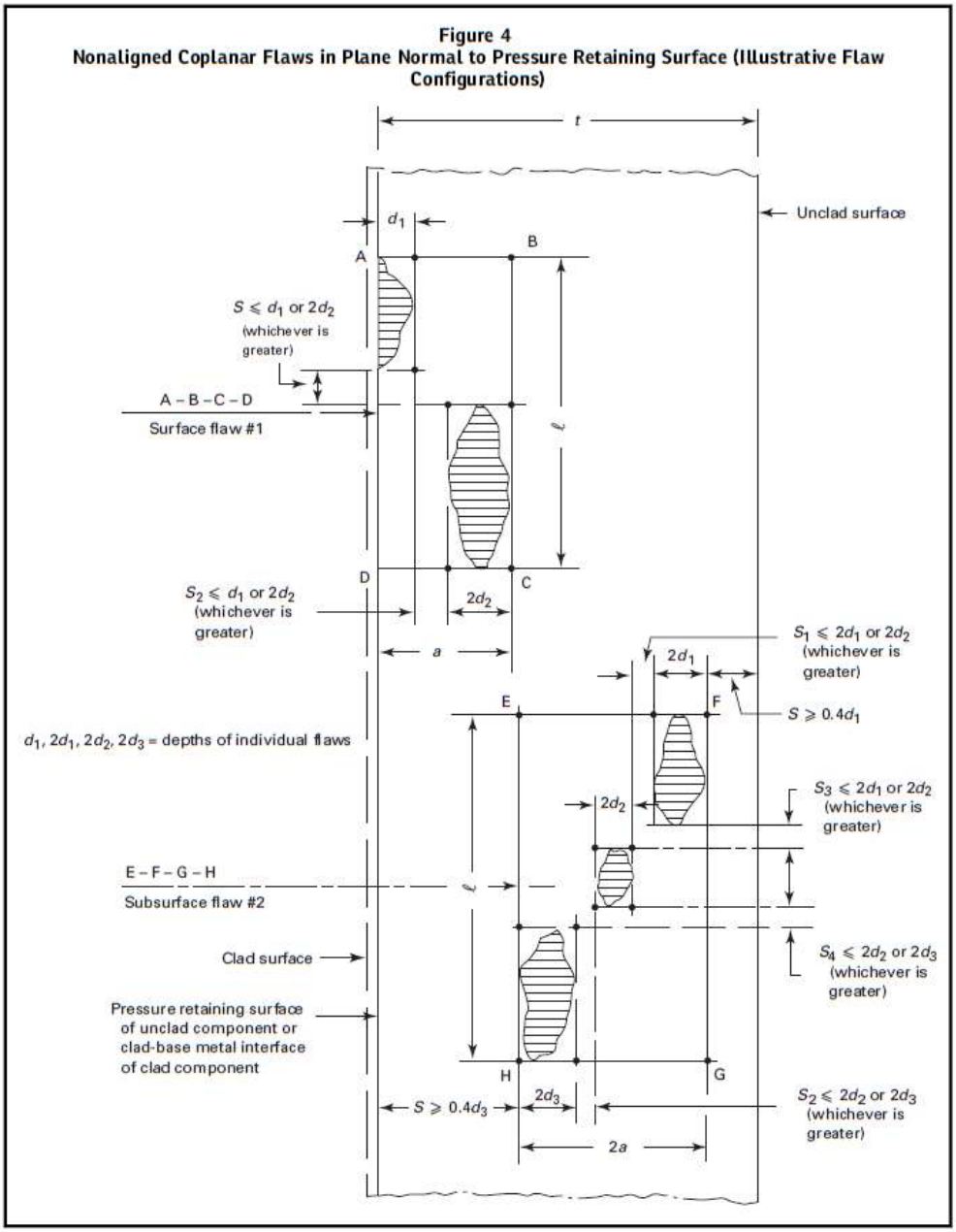
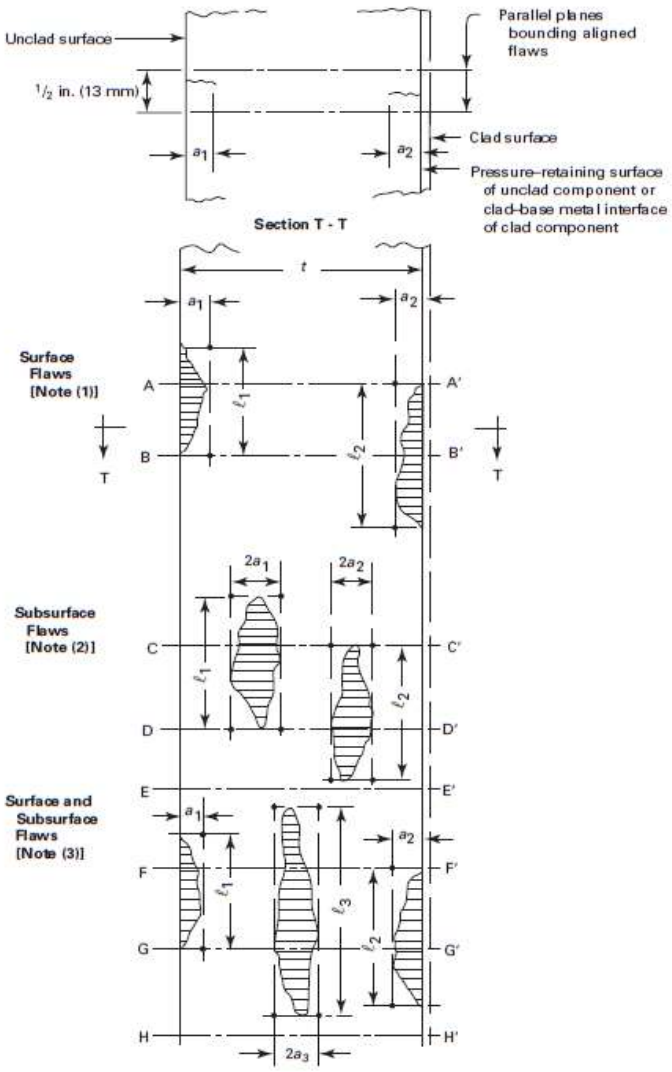


Figure 4
Nonaligned Coplanar Flaws in Plane Normal to Pressure Retaining Surface
(Illustrative Flaw Configurations)

Figure 5
Multiple Aligned Planar Flaws



GENERAL NOTE: In the Notes below, the flaw depth dimensions a_s and a_e are the allowable flaw standards for surface and subsurface flaws, respectively.

NOTES:

(1) This illustration indicates two surface flaws. The first, a_1, is on the outer surface of the component, and the second, a_2, is on the inner surface: $(a_1 + a_2) \le (a_s + a'_s)/2$ within planes A-A′ and B-B′

(2) This illustration indicates two subsurface flaws: $(a_1 + a_2) \le (a_e + a'_e)/2$ within planes C-C′ and D-D′

(3) This illustration indicates two surface flaws and one subsurface flaw:

(a) $(a_1 + a_3) \le (a_s + a'_e)/2$ within planes E–E′ and F-F′

(b) $(a_1 + a_2) \le (a_s + a_e + a'_s)/3$ within planes F–F′ and G-G′

(c) $(a_2 + a_3) \le (a'_s + a_e)/2$ within planes G–G′ and H-H′

Figure 5: Multiple aligned planar flaws

11.4 Data processing

All data will be backed up twice to an appropriate digital medium. The copies will be stored separately. The first copy contains data as collected, i.e. unprocessed data. In case of processing of data, this is recorded on the second disk (together with the unprocessed data)

11.5 Re-examination after repair

In the case of a repair, the repaired area and 100 mm either side of this area shall be re-examined in accordance with this procedure and using the original technique as with the primary examination

12. REPORTING

The test report shall include a reference to this Technical Specification and shall give, as a minimum, the following information:

1) Item no. and weld seam no.
2) Applicable procedure No. and Rev. No.
3) TOFD & PAUT equipment Identification (type, manufacturer, serial no., version no.).
4) Search unit's identification (Probe: frequency, angle, size, serial no.).
5) Beam angles used
6) Couplant (brand name, type)
7) Identification and location of weld or volume scanned
8) Examination conditions (Gain, Probe Center Separation).
9) Surface from which examination was conducted, including surface condition.
10) Areas of restricted access or inaccessible weld.
11) Examination personnel identify and, when required by referencing code section, qualification level
12) Data of examination
13) Recording Indication Reject table indication shall be recorded. As a minimum, the type of indication, location, and extent shall be recorded.
14) The detailed co-ordinate/reference system
15) The detailed scan plans
16) Probe center spacing (PCS)

17) Flaw height, if specified

13. TOFD INSPECTION

13.1 INTRODUCTION

This document covers the general requirements for equipment and procedures to carry out semi-mechanized ultrasonic Time of Flight Diffraction (TOFD) inspection.
The inspection method is chosen mainly for the following reasons:
-Permanent record by means of data storage on disk for future reference and comparison with In Service Inspection results
-Improved inspection sensitivity due to the insensitivity to defect orientation
-Improved inspection accuracy
-Proof of coverage by means of encoded positioning

13.2 Documented examination strategy or scan plan

The work instruction shall document the examination strategy or scan plan per weld thickness and/or weld configuration showing transducer placement and component coverage that provides a standardized and repeatable methodology for weld acceptance.
The scan plan shall also include ultrasonic beam angle used, beam directions with respect to weld center line, and material volume examined for each weld, the limitations due to the TOFD near surface dead zone and the back-wall locus curve.
The documentation shall be made available to the owner upon request.
Appendix II illustrate the TOFD and PAUT Scan plans

13.3. EQUIPMENT CHECKS/SETTINGS

13.3.1 WORK INSTRUCTION AND TOFD SET-UP VALIDATION

A set-up is defined by the probe centre separation, offset, element centre frequency, and element diameter and wedge angle. The number and configuration of set-ups required for flaw detection purposes will depend on geometry of, and access to the item under test. In order to satisfactorily cover the inspection volume of interest, more than one set-up may be required. If the volume of interest is wide, several scans using the same set-up, each displaced from one another (off-set), may also be required.
The initial set-ups shall be based upon experience, modelling, or other data and described in a work instruction. The initial set-ups shall be validated at the start of the project. A validation block with artificial defects as described in Appendix I will be used.
Calibration blocks are designed in such a way that one notch on the side of the block representing the vessel O.D and one notch on the side of the block representing the vessel I.D and one Side drilled holes as a subsurface flaw. Calibration blocks will also be used as validation blocks
The validation shall be considered satisfactory if all the required artificial defects have been detected, and that the indicated length of all sized flaws is 100 % to 110 % of the actual length of the flaws. If not, all artificial defects have been detected, equipment parameters (gain, amplifier band-pass filter, and pulse characteristics) and/or the number and configuration of the initial set-ups shall be adjusted

until the required artificial defects have been detected.
If no defects have been made in the boundaries of the H.A.Z of the validation block, the scan shall be repeated in an offset position which will be equal to the H.A.Z to determine if the setup is capable of finding the same indication if it is located at the edge of the inspection area.
If changes to the number of set-ups or the set-up parameters were required during the validation, the work instruction shall be revised to include the validated set-ups.
Equipment parameters used during the validation shall be the reference parameters for the inspection.

13.3.2 TOFD TIME WINDOW CALIBRATION (SCANNER CALIBRATION)

The Time Window Calibration Scans are to be performed prior to and after completion of scanning as well as prior to and after any change in Probe Centre Separation (PCS). A calibration scan shall be collected and stored, by placing the probes on the side faces of the calibration/validation block and collecting a minimum of 20 A-scans without moving the probes such that the lateral wave and direct compression wave reflection from the far surface are contained within the resultant image.
The difference between the measured wall thickness during the pre-scanning calibration and the actual wall thickness of the calibration block shall not be more than 1% of the actual wall thickness or 1 mm, whichever is the greatest.

The value used for the PCS may differ 1 mm from the required PCS in the scan plan, provided that the above-mentioned requirement is met.
In case of any change in equipment settings, calibration checks shall be carried out in accordance with the above.
If the difference between the wall thickness measured during the TOFD post scanning calibration and the TOFD pre scanning calibration is more than 1% or 0.2 mm whichever is greatest, all scans performed since the last acceptable calibration check shall be repeated.

13.3.3 TOFD SENSITIVITY SETTINGS AND CONFIRMATION OF SENSITIVITY

13.3.3.1 Setting of Sensitivity

Set the TOFD probes on the surface to be utilized for calibration and set the gain control so that the lateral wave amplitude is from 40 % to 90 % of full screen height (FSH) and the noise level is less than 5-10 % FSH. This is the reference sensitivity setting. For multiple zone examinations when sensitivity setting is not displayed, or barely discernible, set the gain control based solely on the noise level.

13.3.3.2 TOFD confirmation of sensitivity

Checking of sensitivity shall be executed prior to and after completion of scanning using one set-up and in case of any change in equipment. If the post scanning sensitivity check shows a deviation of the sensitivity level in excess of 6 dB from initial sensitivity, all scans performed since the last acceptable sensitivity check shall be repeated.
The reference block shall be used for checking. Alternatively, a smaller block may be used to transfer the sensitivity.
If during scanning the overall sensitivity drops more than 12 dB the reason of this drop should be investigated. If it is found that the drop of sensitivity is due to loss of coupling, the scan shall be re scanned. If the sensitivity drop is due to change in geometry, i.e. from outside bend to inside bend, the scan may be rescanned with adjusted gain levels, to guarantee the minimum required sensitivity at the

weakest part of the scan.
If this is found to be insufficient a new work instruction shall be made to optimize the result. If there is no workable setup possible the area shall be marked as inaccessible in the report.

13.3.4 Calibration and Validation blocks

Calibration/Validation blocks shall be constructed such that at the same time they can serve as calibration block as well as reference block. The reference block drawings are given in Appendix I.
For the qualification, the block shall include at least one surface flaw on the side of the block representing the OD surface, one surface flaw on the side of the block representing the ID surface, and one sub-surface flaw.

13.4. INSPECTION TECHNIQUE

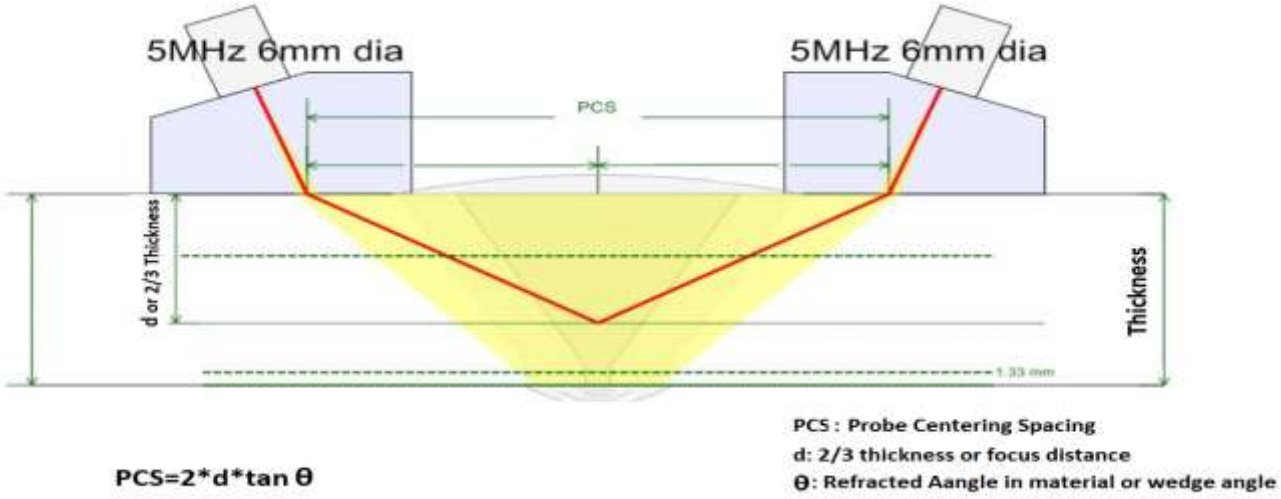
The data shall be collected by moving the probes at uniform speed ensuring the probe array remains central to the weld. The inspection shall be carried out from the outside surface, if obstructions don't allow inspection from the outside alternatively inspection shall be carried out from the inside surface.
The collected data shall be recorded in unprocessed form and presented in D-scan format i.e., vertical axis representing time/depth into the material and the horizontal axis representing distance along the weld. The weld cap is not ground prior to inspection.

13.4.1 INSPECTION VOLUME

The ultrasonic examination area shall include the volume of the weld, plus 25 mm on either side of the weld.
The time-window shall, at all times include the lateral wave, back wall signal and may be the first mode-converted signal. The first mode-converted signal can be used to detect indications outside the area covered by the direct (longitudinal) wave.
When indications are found in the mode converted signal, or when the geometry signal is difficult to interpret due to internal root profile offset scanning may be required to determine the extent and size of such indications, or the condition of the inside bore. If this is insufficient, the weld cap may be flushed and a B scan may be collected to aid in interpretation. Alternately manual Pulse Echo may also be used.

13.4.2 ACCESS RESTRICTIONS

Where access restrictions in close proximity to the weld are present or the weld cap is too wide, other angles and PCS shall be selected to optimise inspection coverage. If this will lead into an increase of PCS of more than 10 %, the actual beam angles in the material vary more than 5 degrees or a change in wedge angles is necessary, a new work instruction shall be made for this weld.
This new work instruction shall be made prior to subsequent scanning of the weld, the setup used shall be validated on the qualification block and the work instruction will be included with the site report for review.

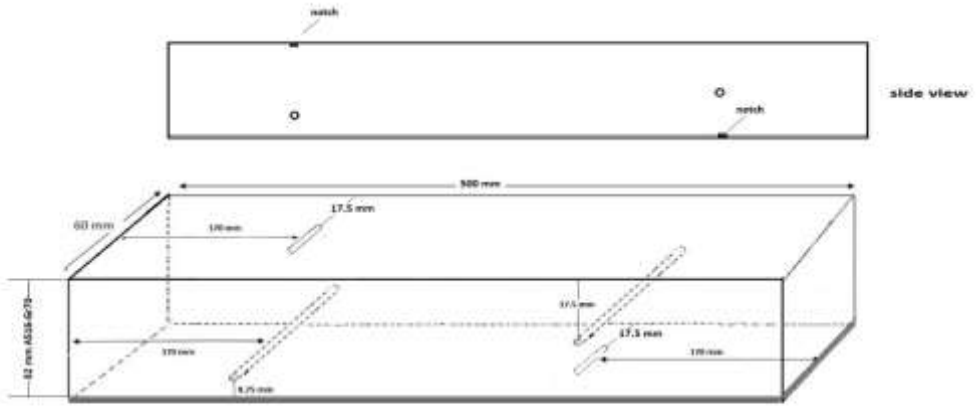


Formula for calculating PCS (probe centering spacing)

13.4.3 SCAN LENGTH

Each scan shall be performed by collecting minimum 1 A-scan every 1 mm of probe travel.
Typically, scans are collected in sections having a length of 1000 mm with an additional 25 mm overlap.
Other scan lengths may be collected by the Level 2 operator for optimised analysis and/or reporting purposes.

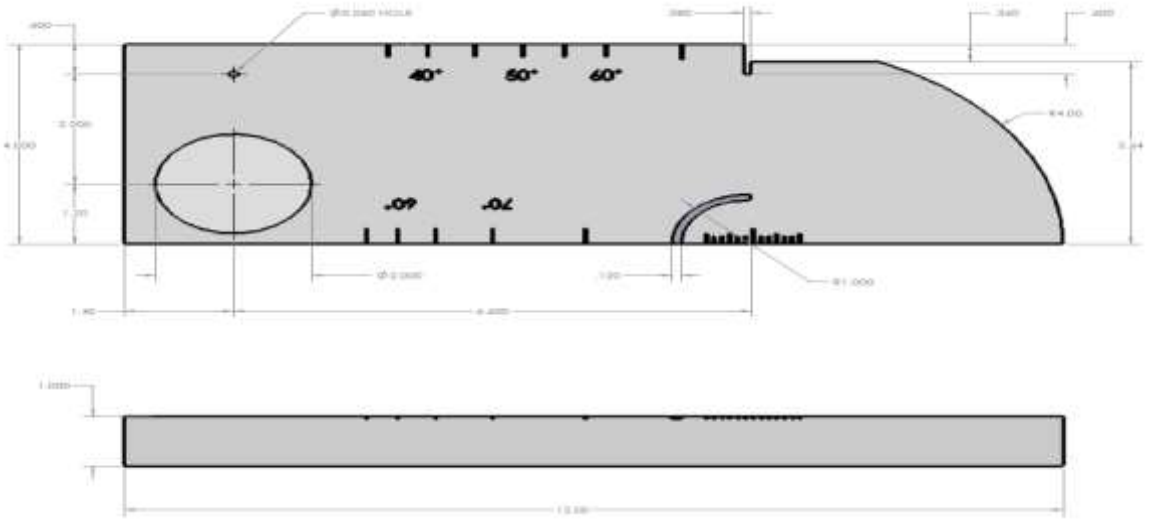
Appendix I. Calibration and Validation blocks



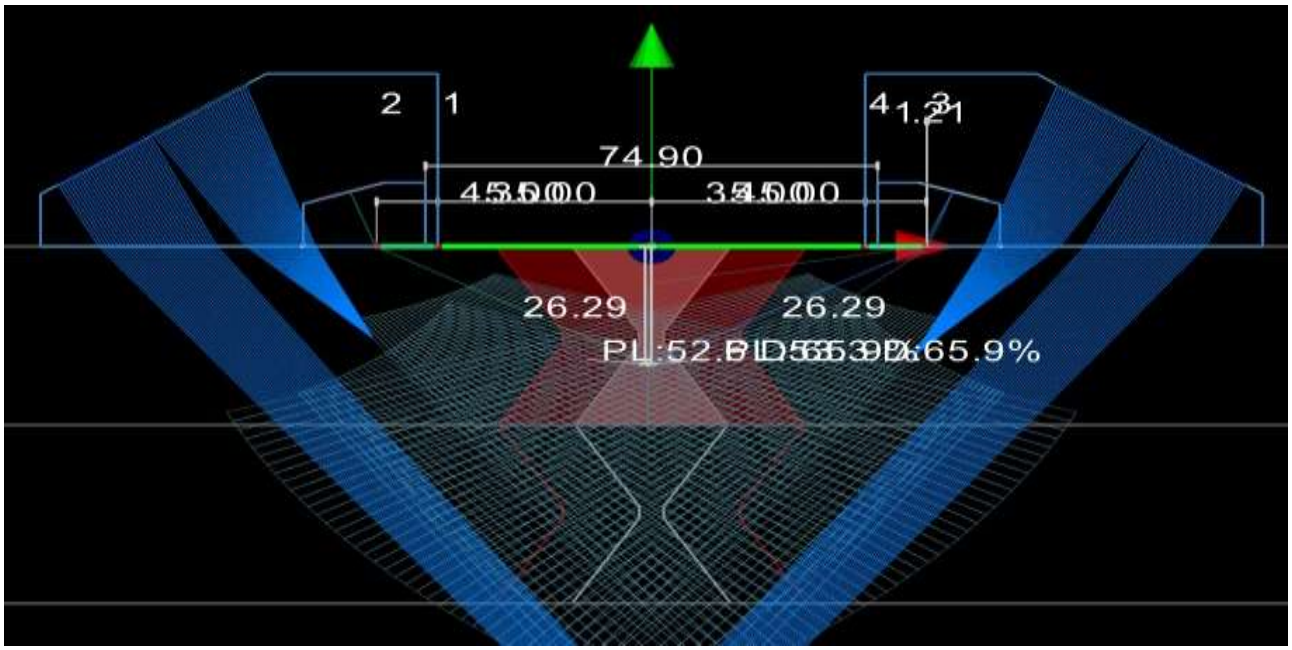
Notch depth = **0.8 mm** **Hole Diameter = 3 mm**
Notch width = **6 mm**
Notch length = **25 mm**

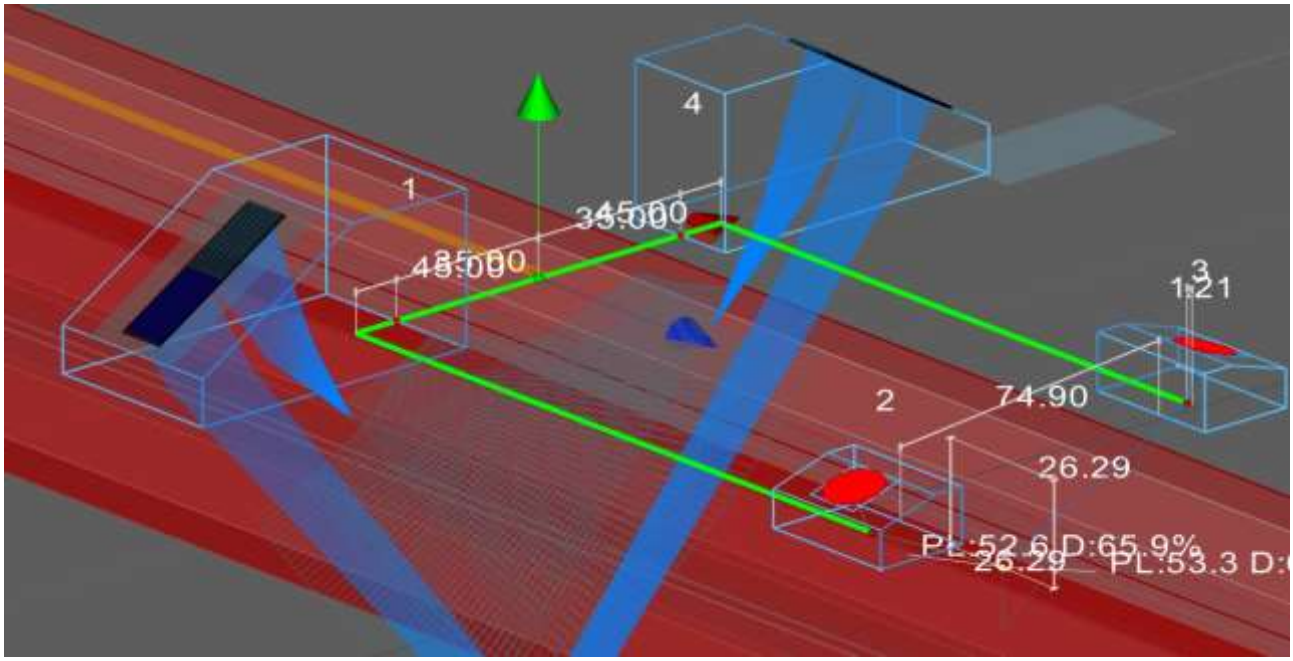
Calibration blocks for thicknesses 33 mm to 45 mm

IIW TYPE I BLOCK

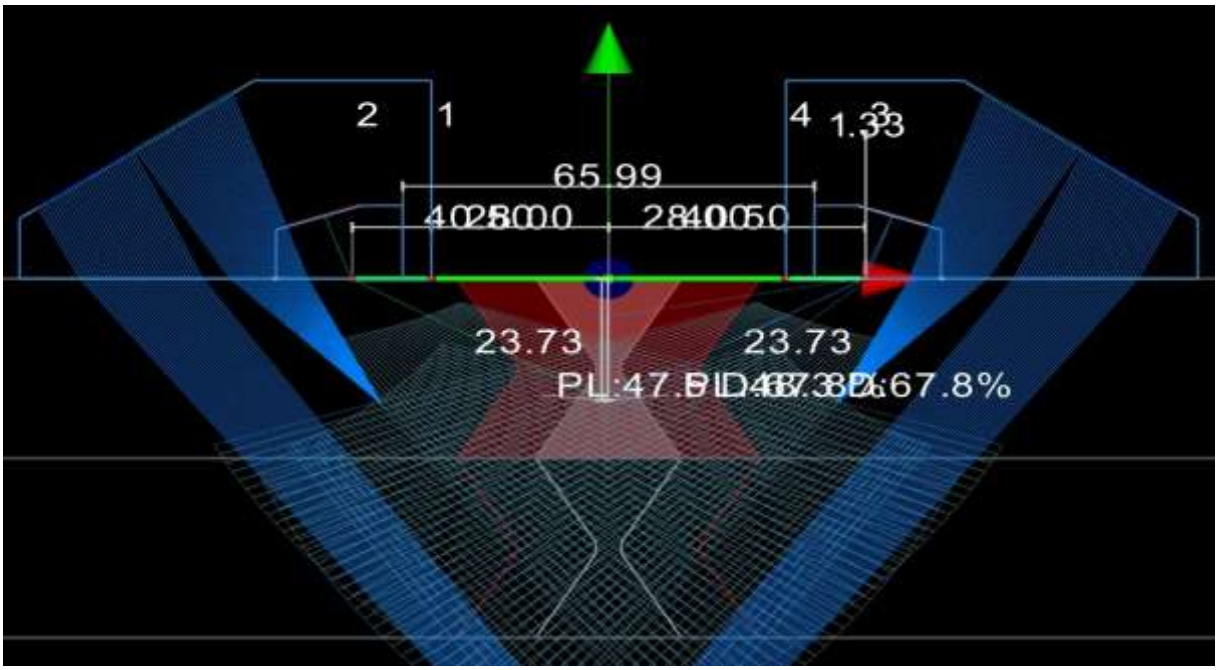


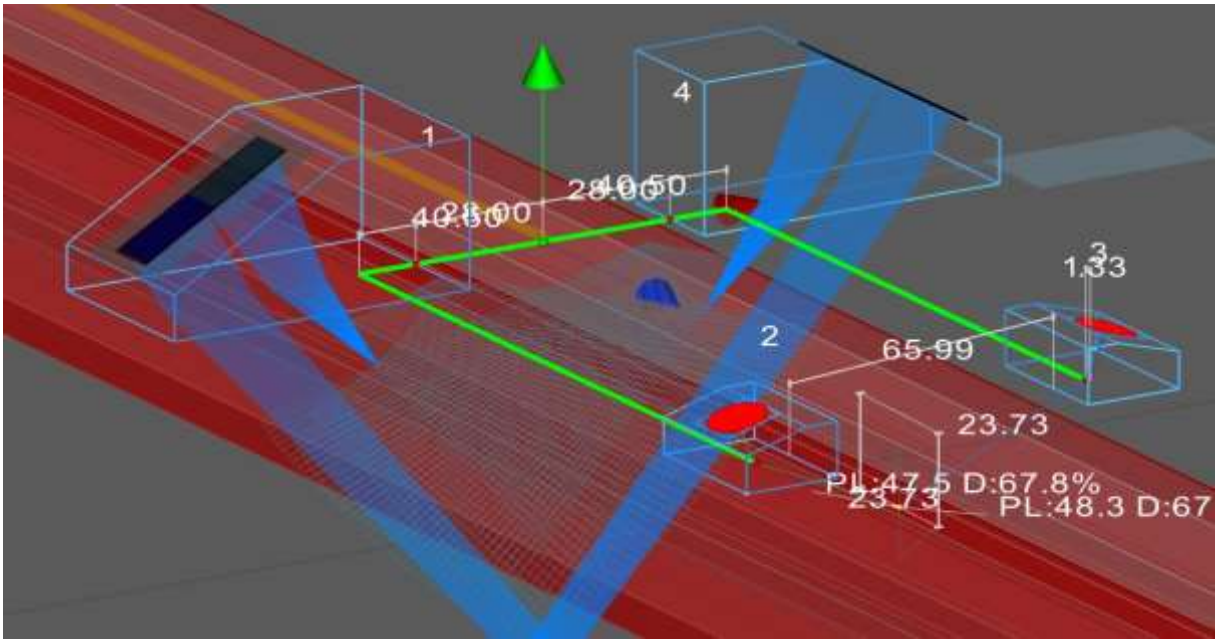
Appendix II. PAUT & ToFD SCAN PLANS

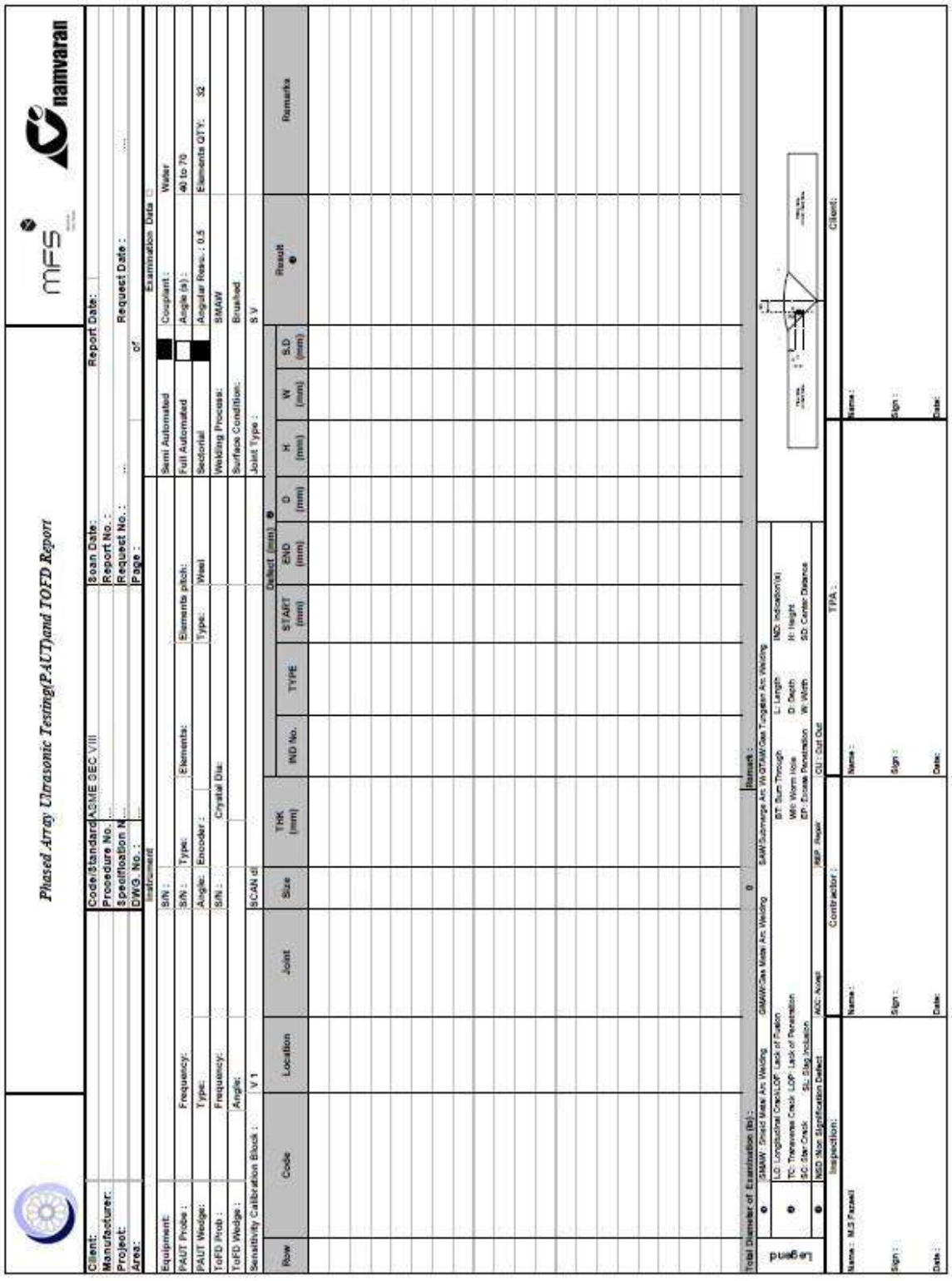




Scan Plan for Thickness 38 mm


2
1
4
3
1.33
65.99
23.73
23.73
PL:47.8 D:67.8%


4
1
3
1.33
2
65.99
23.73
PL:47.5 D:67.8%
PL:48.3 D:67


Phased Array Ultrasonic Testing(PAUT)and TOFD Report
namvaran
mfs
Client:
Manufacturer:
Project:
Area:
Code/Standard: ASME SEC VIII
Procedure No.:
Specification No.:
DWG. No.:
Scan Date:
Report No.:
Request No.:
Page :
Report Date:
Request Date :
of
Examination Data
Instrument
Equipment:
PAUT Probe :
PAUT Wedge:
ToFD Prob :
ToFD Wedge :
Sensitivity Calibration Block :
S/N :
Type:
Frequency:
Angle:
Encoder :
Crystal Dia:
SCAN st
V1
Semi Automated
Full Automated
Sectorial
Welding Process:
Surface Condition:
Joint Type :
Couplant :
Angle (a) :
Angular Rate :
Elements QTY:
Water
40 to 70
0.5
32
SMAW
Brushed
S V
Total Diameter of Examination (Di) :
Remark :
SMAW Shield Metal Arc Welding
GMAW/Gas Metal Arc Welding
SAW Submerge Arc W
GTAW/Gas Tungsten Arc Welding
Legend
Row
Code
Location
Joint
Size
THK (mm)
Defect (mm)
IND No.
TYPE
START (mm)
END (mm)
D (mm)
H (mm)
W (mm)
S.D (mm)
Result
Remarks
LO: Longitudinal Crack/LOF: Lack of Fusion
TC: Transverse Crack LOP: Lack of Penetration
SC: Star Crack
SL: Slag Inclusion
NSD: Non Significative Defect
ACC: Accept
REP: Repair
CU: Cut Out
BT: Burn Through
WH: Worm Hole
EP: Excess Penetration
IND: Indication(s)
L: Length
D: Depth
W: Width
H: Height
SD: Center Distance
TPA :
Inspection:
Contractor :
Name :
Sign :
Date :
Name : M.S Fazaeli
Sign :
Date :