

Management System Document Control Cover Sheet

Document Title	Ref. No.	Revision No.
Procedure for Ultrasonic Testing	SES-26-702	6

	Name	Position	Signature	Date
Reviewed & Approved By:	RAHUL SHARMA	ASNT NDT LEVEL III File no 216723	Rahul Sharma ASNT LEVEL-III UT, RT, MT (ID No.-216723) CSWIP 3.1 Welding Inspector	20.05.2024
Reviewed By	HIDAYAT ULLAH	MANAGER QA/QC	Hidayat Ullah (ID No.-83866) Manager QA/QC	20.05.2024
Prepared By:	FAHEEM ANSARI	DY. MANAGER QA/QC	Faheem Ahmed Ansari (Signature)	20.05.2024

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Document Title : Procedure for Ultrasonic Testing	Revision No. 6
Technical procedure No.:SES-26-702	Date: 20.05.2024

Revision Log Sheet

Revision No.	Effective Date	Description / Summary of Revision
0	23.06.2008	Initial Issue after NOV Sara
1	20.10.2011	Change of name of company from Nov Sara to SARA SAE
2	10.11.2012	Amendments added to highlighted clauses
3	01.04.2017	Removing non- applicable codes and highlighting amended clauses.
4	12.01.2021	Amendment added to bold & Italic Clauses
5	09.07.2021	Revised to include API 6A 21st Ed, Addendum 2 requirements
6	20.05.2024	Incorporated API 16C -3 rd edition and revised as per SNT-TC-1A-2024 requirements

1. PURPOSE

- 1.1. The purpose of this procedure is to establish the requirements for the detection of defects and corrosion in welds & other product forms (Places, Pipe, Forged components, Cast material etc.) using ultrasonic testing.
- 1.2. This procedure provides a system of general conditions and specific instructions as an aid to qualified personnel required to perform ultrasonic inspection.

2. SCOPE

- 2.1. This procedure gives the methods, techniques, quality, and reporting requirements necessary for the ultrasonic testing of welds using the ultrasonic pulse-echo technique.
- 2.2. This procedure covers the ultrasonic testing of fusion welded butt joints in plate and pipe welds, inclusive of the parent metal, weld metal and heat affected zones.
- 2.3. This is the Company approved procedure and shall be adhered to at all times except where the Client or Contract specifies other requirements.

3. DEFINITIONS

- 3.1. Company-SARA SAE PRIVATE LIMITED
- 3.2. Client -Those Companies, or Organizations or Individuals to which the Company is contracted to provide Services.
- 3.3. Contract- The form of agreement for the provision of the services to the Client by the Company.

4. REFERENCES

- 4.1. APIRP2X :2020 - Recommended Practice for UT and Magnetic Examination of offshore Structural Fabrication and Guidelines for Qualification of Technicians.
- 4.2. ASME B31.1-2022 - Power Piping.
- 4.3. ASME B31.3-2022 - Process Piping
- 4.4. ASME V: 2023 - Non-destructive Examination.
- 4.5. ASME VIII :2023- Rules for the Construction of Pressure Vessels Division. 1, 2 & 3.
- 4.6. ASME IX:2023 - Qualification Standard for Welding and Brazing, Procedures, Welders, Brazers and Welding Brazing Operators.
- 4.7. SDP-22-004 - Personal Certification
- 4.8. SDP-27-009 - Control of Non-conforming Products
- 4.9. API Spec 6A - 21st Edition- Specification for Wellhead and Christmas Tree Equipment

Document Title : Procedure for Ultrasonic Testing	Revision 5
Technical procedure No.:SES-26-702	Date: 20.05.2024

- 4.10. API Spec 16A - 4th Edition- Specification for Drill Through Equipment
- 4.11. ***API Spec 16C - 3rd Edition, March 2021- Specification for Choke and Kill Equipment***
- 4.12. ASTM A388 / A388M – 23 - Standard Practice for Ultrasonic Examination of Steel Forgings.
- 4.13. ASTM E127 – 20 (2021)- Standard Practice for Fabrication and Control of Flat Bottomed Hole Ultrasonic Standard Reference Block
- 4.14. ASTM E-213-22 "Standard Procedure for Ultra Sonic Examination of Metal Pipes and Tubing"

5. RESPONSIBILITIES

- 5.1. Manager QA/QC shall be responsible for ensuring that the necessary resources are made available for the requirements of this procedure to be carried out in a safe manner.
- 5.2. Department head shall be responsible for ensuring that the requirements of this procedure are fully implemented at all times.
- 5.3. All employees involved in the implementation of this procedure shall be responsible for adherence to the requirements stated within.

6. PROCEDURE INSTRUCTIONS

6.1. PERSONNEL QUALIFICATION, TRAINING, QUALIFICATION AND CERTIFICATION

The NDT Inspector shall be trained, qualified and certified to a minimum of ASNT Level II in for the particular product forms (Welds, Casting, wrought product & etc.) accordance with SARA SAE Written practice based on **ASNT's SNT-TC-1A- 2024, "Recommended Practice for Non-Destructive Testing Personnel Qualification and Certification (SES-26-743, latest revision)**

7. PROCEDURE QUALIFICATION

- 7.1. When procedure qualification is specified, a change of requirement in Table 1 identified as an essential variable from the specified value, or range of values, shall require re qualification of the written procedure and validation of the technique.
- 7.2. 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.
- 7.3. All changes of essential or nonessential variables from the value, or range of values, specified by the written procedure shall require revision of, or an addendum to, the written procedure.
- 7.4. The extent of examination shall be specified by the customer or the referencing Code Section.

Table 1: REQUIREMENTS OF AN ULTRASONIC EXAMINATION PROCEDURE

Document Title : Procedure for Ultrasonic Testing	Revision 5
Technical procedure No.:SES-26-702	Date: 20.05.2024

Requirement	Essential Variable	Nonessential Variable
Weld configurations to be examined, including thickness dimension and base material product from (pipe, Plate, etc.)	✓	---
The surface from which the examination shall be performed	✓	---
Technique(s) (Straight beam, angle beam, contact, and/or immersion)	✓	---
Angle(s) and mode(s) of wave propagation in the material	✓	---
Search unit type(s), frequency(ies), and element size(s) / shape(s)	✓	---
Ultrasonic instrument	✓	---
Calibration [calibration block(s) and technique(s)]	✓	---
Direction and extent of scanning	✓	---
Scanning (Manual vs. automatic)	✓	---
Method for discriminating geometric from flaw indications	✓	---
Method for sizing indication	✓	---
Scan overlap (decrease only)	✓	---
Personnel performance requirements, when required	✓	---
Personnel qualification requirements	NA	✓
Surface condition (Examination surface, calibration block)	NA	✓
Couplant: brand name or type	NA	✓
Post-examination cleaning technique	NA	✓
Records, including minimum calibration data to be recorded (e.g., instrument setting)	NA	✓

8. EQUIPMENT

8.1. ULTRASONIC INSTRUMENT

8.1.1. Only pulse echo type ultrasonic flaw detectors which incorporate "A" scan CRT presentation with direct contact coupling shall be used.

8.1.2. The instrument shall be capable of fulfilling the following performance criteria

- Screen height linearity shall not exceed $\pm 5\%$ deviation of full scale reading for all values from 20 to 80% full scale height.
- Amplitude control linearity shall be within the permissible tolerances as mentioned below.

Indication set at % of Full Screen	dB Control Change	Indication Limits % of Full Screen

Document Title : Procedure for Ultrasonic Testing	Revision 5
Technical procedure No.: SES-26-702	Date: 20.05.2024

80%	-6dB	32 to 48%
80%	-12dB	16 to 24%
40%	+6dB	64 to 96%
20%	+12dB	64 to 96%

The checks shall be carried out every 1 year for digital instruments & every 3 months for Analog instruments.

- 8.1.3. To enable the performance of instruments to be monitored, each instrument shall have a unique serial number.
- 8.1.4. All the original calibration certificates held at the Company Head Office, a photocopy to accompany each ultrasonic instrument while using at sites.
- 8.1.5. Instruments that do not meet the requirements shall be withdrawn from service until corrected.

9. PROBES

- 9.1. Compression straight beam probes shall have a nominal frequency of 1.0 to 5 MHZ, 10- or 25.4-mm Diameter.
- 9.2. Shear wave angle beam probes shall have a nominal frequency of 1.0 to 5.0 MHZ, Size 8×9 or 20×22 mm.
- 9.3. The frequency chosen shall be as high as possible consistent with obtaining satisfactory transmission used shall be capable of ensuring maximum ultrasound
- 9.4. The couplant transmission similar as calibration
- 9.5. Both compression straight beam probes shall have the ability to resolve clearly 3 indications from the IOW calibration block.
- 9.6. Probe crystals may be either round, square or rectangular. Both single and twin crystal probes may be used.

The following shall be established for each probe An accurate probe index rechecked before each ultrasonic operation.

THICKNESS RANGE	PRODUCT FORMS	FREQUENCY
COMPRESSION WAVE		
Upto 60 mm	Plate, Pipe, forging	4 to 5 MHz
Upto 60mm	Casting/coarse grain material	2 to 4MHz
Greater than 60mm	Plate, Pipe, Forging	2 to 4MHz
Greater than	Casting	1 to 4MHz

Document Title : Procedure for Ultrasonic Testing	Revision 5
Technical procedure No.:SES-26-702	Date: 20.05.2024

60mm		
SHEAR WAVE		
10-35mm	Welds	2 to 4MHz
Above 35 mm	Welds	2 to 4MHz

9.7. COUPLANT

- 9.7.1. The couplant used shall be capable of ensuring maximum ultrasound transmission.
- 9.7.2. The couplant used shall be the same for both calibration and examination.
- 9.7.3. Cellulose paste, liquid soap, glycerin, light machine oil or suitable equivalent may be used providing they are non-injurious to material under test.

9.8. REFERENCE AND CALIBRATION STANDARDS as per 16A

- 9.8.1. Calibration blocks shall be of substantially the same material as that under test, and whenever practical, the application of a transfer correction, as addressed in the written procedure, is applied to the scanning surface when variation in acoustic response of 2 dBs occurs due to surface finish difference between the test block and the part to be examined, a coupling compensation of up to 12 dB maximum shall be performed. It's surface is not representative of the reference standard surface.
- 9.8.2. Calibration blocks shall be the same thickness $\pm 25\%$ as the casting to be examined.
- 9.8.3. Calibration shall be performed from the surface clad or unclad, convex or concave (0.9 to 1.1 time of curvature) corresponding to the surface of the material from which the examination will be performed.
- 9.8.4. Temperature difference between test material and calibration block shall be within 14°C.
- 9.8.5. The following calibration blocks shall be used for calibration of equipment
 - a) International Institute of Welding VI block.
 - b) Miniature Block / V2 block.
 - c) Institute of Welding IOW-Beam Profile Block.

Weld Thickness (mm)	Basic Calibration Block Thickness (mm)	Hole Diameter (mm)
25.4 or Less	19.05 or T	2.38
Over 25.4 to 50.8	38.10 or T	3.00
Over 50.8 to 101.6	76.20 or T	4.76
Over 101.6 to 152.4	127.0 or T	6.35
Over 152.4 to 203.2	177.8 or T	7.83
Over 203.2 to 254	228.6 or T	9.42
Over 254	T	See note 1

For each increase in thickness of 50.8mm or fraction thereof over 254mm, the hole diameter shall increase 1.5mm

9.9. API Calibration requirement as per 6A

Distance amplitude curve (DAC) shall be based on following

- a) Max 1.6mm (1/16 in.) flat-bottom hole for metal thicknesses through 38 mm (11/2").
- b) Max 3.2mm (1/8 in.) flat-bottom hole for metal thicknesses from 38mm (11/2") through 150mm (6")
- c) Max 6.4mm (1/4 in.) flat-bottom hole for metal thicknesses exceeding 150mm (6")
- d) Max 1.6 mm (1/16 in.) and 25 mm deep side drill hole for angle beam technique.
- e) Max 3.2mm (1/8") FBH for straight beam and 1.6mm (1/16") SDH for angle beam DAC shall be used for Stem.
- f) The weld overlay volumetric inspection 3mm FBH for bond integrity examination requirements to PSL 3 and PSL 4.

NOTE - The weld overlay volumetric inspection requirements do not apply to PSL 1 and PSL 2. The entire volume of weld overlay plus the 3 mm (0.12 in.) of adjacent base metal on all sides shall be examined using ultrasonic examination after heat-treatment for mechanical properties and prior to machining operations.

9.10. API Calibration requirement as per 16A, 16C

After Calibration as per Clause.12, below calibration requirement shall be satisfied before examination

Distance amplitude curve (DAC) shall be based on following

- a) 1.6mm (1/16 in.) flat-bottom hole for metal thicknesses 25mm(1") through 38 mm (11/2").
- b) 3.2mm (1/8 in.) flat-bottom hole for metal thicknesses from 38mm (11/2") through 150mm (6")
- c) 6.4mm (1/4 in.) flat-bottom hole for metal thicknesses exceeding 150mm (6")
- d) 1.6 mm (1/16 in.) and 25 mm deep side drill hole for angle beam technique.
- e) 3.2mm (1/8") FBH for straight beam and 1.6mm (1/16") SDH for angle beam DAC shall be used for Stem.
- f) For API 16C rigid piping the notch depth of 5% of pipe wall thickness, having 25.4mm (max.) length of 1 mm (max.) notch width.

10. INFORMATION REQUIREMENTS

10.1. The NDT Operator shall be supplied with the following details of the item to be examined before testing commences

- a) Material type.
- b) Joint details.
- c) Welding process.
- d) P.W.H.T. (if any).

The NDT Operator shall verify the extent of examination coverage and record any limitation of the test on the Test Report.

Document Title : Procedure for Ultrasonic Testing	Revision 5
Technical procedure No.:SES-26-702	Date: 20.05.2024

11. SURFACE CONDITION

- 11.1. Surfaces used for testing shall be free from weld spatter, scale or other irregularities which could impair adequate acoustic coupling.
- 11.2. Depending on the profile and condition of the weld face, dressing may be necessary to avoid the production of confusing surface echoes.
- 11.3. When the selected ultrasonic beam cannot cover the full cross section of the weld without the probe impinging up on the weld face, the weld face shall be ground smooth to proceed with testing on approval from the relevant contracting authority, else a limitation will be noted on the Test Report.

12. CALIBRATION FOR EXAMINATION

- 12.1. The Reject control shall be turned off for calibration and during examination.
- 12.2. Calibration shall be conducted for sensitivity and beam path distance prior to commencement of testing.
- 12.3. Calibration for straight beam testing shall encompass and present at least two material thicknesses on the CRT screen. Sensitivity shall be adjusted so that the indication back wall reflection is 80% full screen height.
- 12.4. Time base calibration for angle beam testing shall be adjusted to represent the maximum sound path distance covered.
- 12.5. Sensitivity levels of shear wave probes shall be in accordance with the relevant Specification.

13. TESTING PROCEDURES

- 13.1. Prior to examination all specimens shall be marked with a reference datum line.
- 13.2. Parent Metal Examination
 - a) The area of the parent metal on either side of the weld used for scanning shall be checked for laminations prior to angle probe testing using a compression wave probe.
 - b) The area to be checked shall be large enough to detect laminar defects that could interfere with shear wave propagation.
 - c) The lamination scan shall be carried out regardless of whether the parent metal has been ultrasonically tested previously.
 - d) During the lamination scan attenuation characteristics, material thickness and any flaws found shall be noted and recorded if necessary.
 - e) Sensitivity level shall be as described as above.
 - f) Evaluation of indications shall be made using the 6dB drop technique.
- 13.3. Shear Wave Examination
 - a) Standard sensitivities shall be in accordance with the relevant Specification. All examination sensitivities shall be conducted at 6 dB above standard sensitivity.

Document Title : Procedure for Ultrasonic Testing	Revision 5
Technical procedure No.:SES-26-702	Date: 20.05.2024

- b) The length of the scans shall be selected in such a way that the ultrasonic energy travels through the weld and the H.A.Z
- c) Hollow forgings (that have an axial length greater than 50mm and an outside to inside diameter ratio of less than 2.0 or 1) by angle beam technique from outside diameter surface
- d) All scans must overlap by 10% crystal diameter
- e) Scanning speed shall not exceed 150 mm/sec.
- f) A Zig-Zag scanning pattern shall be employed throughout.
(0 All flaws shall be evaluated at standard sensitivity)
- g) The sizing of flaws shall be carried out using the beam boundary technique.
- h) Height of flaws shall be sized by the 20 dB drop technique and length shall be sized by the 6 dB drop technique.
- i) Unless otherwise specified 100% of the weld length shall be tested.

14. SCANNING TECHNIQUES

- 14.1. The maximum scanning rate shall be 150mm per second.
- 14.2. Scanning techniques shall consist of
 - a) Compression probe scan of parent material in accordance with 13.2.
- 14.3. Angle beam scan of weld metal using appropriate angled probes.
- 14.4. As a minimum each pass of the probe shall overlap a minimum of 10% of the transducer width.
- 14.5. For scanning purposes, the sensitivity shall be set 6 dB higher than the standard sensitivity. When an indication is noted, the sensitivity shall be adjusted to the standard sensitivity.
- 14.6. Whenever feasible the examination shall be carried out from both sides of the weld.
- 14.7. The beam shall be pointed at the weld length normally.
- 14.8. As a minimum two (2) different angle probes shall be used.
- 14.9. In addition, the 45° probe shall be used for "angled" scanning of the weld to search for transverse flaws.

15. ACCEPTANCE STANDARDS

- 15.1. Acceptance standards shall be in accordance with the appropriate Specification or to Clients requirements.

15.2. API 6A PSL-2

15.2.1. Weld NDE — Volumetric

- No indication whose signal amplitude exceeds that of the reference level.
- No linear indication interpreted as cracks, incomplete joint penetration or incomplete fusion

Document Title : Procedure for Ultrasonic Testing	Revision 5
Technical procedure No.:SES-26-702	Date: 20.05.2024

- No slag indication with amplitudes exceeding the reference level whose length exceeds those given in Table No. 1

Table No. 01 — Maximum amplitude of slag indications

Weld thickness T_a Mm		Inclusion length mm (in)	
19,0	(0,75)	6,4	(0,25)
19,0 to 57,0	(0,75 to 2,25)	0,33 T	(0,33 T)
57,0	(2,25)	19,0	(0,75)

a T is the thickness of the weld being examined. If a weld joins two members having different thicknesses at the weld, T is the thinner of the two thicknesses.

15.2.2. API 6A PSL-3/3G

- All requirement is identical to the requirements for PSL-2, with the addition that all repair welds, if the repair exceeds 20% of the original wall thickness of 25 mm (1 in.), whichever is the smaller, or if the extent of the cavity exceeds approximately 65 cm² (10 in.²), shall be examined after all welding and post-weld heat treatment.

15.2.3. API 6A PSL-4

- Acceptance criteria is same as specified for PSL-3/3G with addition that no continuous cluster of indications on the same plane, regardless of amplitude, shall be found over an area twice the diameter of the search unit.

15.2.4. Weld overlay NDE — Volumetric

- Weld overlay shall be examined using ultrasonic examination.

The acceptance criteria shall be as follows:

- no single indication exceeding reference DAC;
- no multiple indications exceeding 50 % of reference DAC.

NOTE "Multiple indications" is defined as two or more indications (each exceeding 50 % of the reference DAC) within 13 mm (1/2 in.) of each other in any direction

15.3. API 16A

Weld NDE-Volumetric Examination of Fabrication Welds

- Any indication whose signal amplitude exceeds the reference level
- Any linear indication interpreted as a crack, incomplete joint penetration, or incomplete fusion
- Any slag indication with amplitude exceeding the reference level whose length exceeds that specified in Table No.01.

Table No. 01

Weld thickness t		Inclusion Length	
mm	(in)	mm	(in)

Document Title : Procedure for Ultrasonic Testing	Revision 5
Technical procedure No.:SES-26-702	Date: 20.05.2024

PAGE 11 of 14

< 19	<0.76	6.4	0.25
$19 \leq t \leq 57$	$0.76 \leq t \leq 2.25$	$0.33t$	$0.33t$
> 57	> 2.25	19.0	0.75

- No single indications exceeding reference distance amplitude curve.
- No multiple indications exceeding 50% of reference distance amplitude curve

Note: Multiple indications are defined as two or more indications (each exceeding 50% of the reference curve) within 13 mm (1/2 in.) of each other in any directions

15.4. API 16A

15.4.1. Weld NDE-Volumetric Examination of Fabrication Welds

- ✓ Discontinuities which produce an indication greater than 20% of the reference level shall be investigated with shape, identity and location and evaluate
- ✓ Discontinuities evaluated as linear crack, lack of fusion, incomplete penetration or incomplete joint are unacceptable regardless of its size.
- ✓ Any other indication with amplitude exceeding the reference level whose length exceeds that specified in Table No.02.

Table No. 02

Weld thickness t		Inclusion Length	
mm	(in)	mm	(in)
< 19	<0.76	6.4	0.25
$19 \leq t \leq 57$	$0.76 \leq t \leq 2.25$	$0.33t$	$0.33t$
> 57	> 2.25	19.0	0.75

Note: If a weld joints two parts having different thickness at weld, t is taken as the thinner of two thickness

15.4.2. Volumetric NDE for forgings/ Parts (For PSL 2,3 & 4)

- ✓ No single indications exceeding reference distance amplitude curve (DAC).
- ✓ No multiple indications exceeding 50% of reference distance amplitude curve (DAC). Multiple indications are defined as two or more indications (each exceeding 50% of the reference curve) within 13 mm (1/2 in.) of each other in any directions.
- ✓ No continuous cluster of indications on the same plane, regardless of amplitude, shall be found over an area twice the diameter of the search unit (For PSL 4 Only).

15.5. API 16C

15.5.1. Volumetric NDE

- ✓ No single indications exceeding reference distance amplitude curve.
- ✓ No multiple indications exceeding 50% of reference distance amplitude curve. Multiple indications are defined as two or more indications (each

Document Title : Procedure for Ultrasonic Testing	Revision 5
Technical procedure No.:SES-26-702	Date: 20.05.2024

exceeding 50% of the reference curve) within 13 mm (1/2 in.) of each other in any directions.

15.5.2. Weld NDE

- ✓ No single indications exceeding reference distance amplitude curve.
- ✓ No linear indications interpreted as cracks, incomplete joint penetrations or incomplete fusion.
- ✓ No slag indications with amplitudes exceeding the reference level whose length exceeds Table No. 03

Table No. 03

Weld Thickness T	Inclusion length
Less than 0.76 (19.3)	0.25 (6.4)
0.76 (19.3) to 2.25 (57.2)	0.33 T
Greater than 2.25 (57.2)	0.75 (19.1)

16. EXAMINATION OF REPAIRS

- 16.1. Repairs shall be re-examined using the same procedure utilised for the original examination.
- 16.2. The extent of the examination shall include the repaired area of the weld plus 100mm at either end of the repaired section.
- 16.3. A new report, with relevant repair number, shall be written for all repaired welds retested.

17. POST INSPECTION CLEANING

- 17.1. When required, post inspection cleaning shall be accomplished to remove residual inspection materials (couplant) by flushing with a solvent based cleaner then finally wiping with rags.

18. REPORTING

- 18.1. Reporting requirements shall be as specified by the Client or the Contract Document.
- 18.2. Reports shall be completed for each and every examination on the same day that testing was carried out.
- 18.3. Indications shall be sentenced in accordance with the applicable Specification and shall be supported by drawings indicating size i.e. length, cross section and orientation.
- 18.4. Flaws shall be classified as planar, linear or spherical and every effort shall be made to state the nature of the defect.
- 18.5. In the absence, compilation of report shall be according but not limited to the following: -
 - a) job Order Card (if applicable)
 - b) Client Information (if applicable)
 - c) Inspection Reports

Document Title : Procedure for Ultrasonic Testing	Revision 5
Technical procedure No.:SES-26-702	Date: 20.05.2024

13.1 UT subcontractors must use this examination method and acceptance criteria in Performing the examination.

19. SAFETY

19.1. Care shall be exercised during inspection with due regard to the fact that the standard Ultrasonic Flaw Detectors used by the Company are NOT considered intrinsically safe and Hot Work Permits shall be required for hazardous areas.

19.2. ANNEX 'A'- WORK SHEET FOR MANUAL ULTRASONIC TESTING

Document Title : Procedure for Ultrasonic Testing	Revision 5
Technical procedure No.:SES-26-702	Date: 20.05.2024