

Engineering Procedure

SAEP-1146

31 August, 2004

Manual Ultrasonic Thickness Testing

Non-destructive Testing Standards Committee Members

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Saudi Aramco DeskTop Standards

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1 Scope

- 1.1 This Engineering Procedure provides the general instructions for **manual** ultrasonic thickness testing (UTT) of base materials in plates, tubing, pipes, tanks, vessels, castings and forgings having a nominal wall thickness of 0.050 inch (1.2 mm) to 6.0 inches (150 mm) in accordance with the referenced Codes and Standards.
- 1.2 This procedure is limited to contact testing using longitudinal wave techniques only.
- 1.3 This Engineering procedure applies to Saudi Aramco NDT personnel, and to contractor personnel seconded to Saudi Aramco on an In-Kingdom inspection contract, conducting UTT examination on behalf of Saudi Aramco.
- 1.4 This procedure does not apply to NDT contractors performing UTT for vendors on LSTK projects unless specified in contract or purchasing documents.

2 Conflicts and Deviations

- 2.1 Any conflicts between this procedure and other Saudi Aramco Engineering Standards (SAES's), Materials System Specifications (SAMSS's), Standard Drawings (SASD's), or industry standards, codes, and forms shall be resolved in writing by the Company or Buyer Representative through the Manager, Inspection Department of Saudi Aramco, Dhahran.
- 2.2 Direct all requests to deviate from this procedure in writing to the Company or Buyer Representative, who shall follow internal company procedure [SAEP-302](#) and forward such requests to the Manager, Saudi Aramco Inspection Department.

3 References

- 3.1 Saudi Aramco References

Saudi Aramco Engineering Procedures

[SAEP-302](#)

*Instructions for Obtaining a Waiver of a
Mandatory Saudi Aramco Engineering
Requirement*

[SAEP-1140](#)

*Qualification and Certification of Saudi Aramco
NDT Personnel*

[SAEP-1142](#)

*Qualification and Certification of Non-Saudi
Aramco NDT Personnel*

3.2 Applicable Industry Codes and Standards (latest editions and addenda)

American Society of Mechanical Engineers (Boiler and Pressure Vessel Codes)

<i>ASME SEC I</i>	<i>Rules for Construction of Power Boilers</i>
<i>ASME SEC V Article 5</i>	<i>Ultrasonic Examination Methods for Materials and Fabrication</i>
<i>ASME SEC V Article 23</i>	<i>Ultrasonic Standards</i>
<i>ASME SEC V Article 30</i>	<i>Terminology for Nondestructive Examination Standards</i>
<i>ASME SEC VIII</i>	<i>Rules for Construction of Pressure Vessels</i>
<i>ASME B31.1</i>	<i>Power Piping</i>
<i>ASME B31.3</i>	<i>Chemical Plant and Petroleum Refinery Piping</i>
<i>ASME B31.4</i>	<i>Liquid Transportation Systems for Hydrocarbons</i>

American Society for Testing and Materials

<i>ASTM E1316-91c</i>	<i>Specification of Terminology for Nondestructive Examination</i>
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American Petroleum Institute

<i>API STD 510</i>	<i>Pressure Vessel Inspection Code</i>
<i>API STD 570</i>	<i>Piping Inspection Code</i>
<i>API STD 620</i>	<i>Design and Construction of Large, Welded, Low Pressure Storage Tanks</i>
<i>API STD 650</i>	<i>Welded Steel Tanks for Oil Storage</i>
<i>API STD 653</i>	<i>Tank Inspection, Repair, Alteration, and Reconstruction</i>
<i>API STD 1104</i>	<i>Welding of Pipelines and Related Facilities</i>

4 Personnel Qualifications

- 4.1 Saudi Aramco personnel shall be qualified and certified in accordance with [SAEP-1140](#).
 - 4.2 Contractor Personnel shall be qualified and certified in accordance with [SAEP-1142](#).
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5 Equipment

- 5.1 **Instruments:** The UTT instrument shall have an A-scan display to assist the operator in discrimination of test results. Only portable hand held Ultrasonic thickness testers from the Saudi Aramco approved equipment list (contact Saudi Aramco NDT Unit Supervisor for the most recent Approved Equipment List) are acceptable, see Appendix 1. Approved Ultrasonic flaw detectors equipped with electronic gate and digital thickness display may be used.
- 5.2 **Transducers:** shall be within the manufacturers operating specifications for the instrument being used. When selecting a transducer consideration shall be given to the surface temperature, expected thickness of the specimen and the resolution required. Transducers may contain either single or dual elements. Digital thickness meters with A-scan presentation shall use only manufacturer's provided transducers.
- 5.3 **Calibration Blocks:** shall have a sound velocity within $\pm 5\%$ of the material to be tested. Use of SAMMS 4340 material is acceptable for most carbon and stainless steel applications. When absolute precision is required calibration shall be performed on blocks made of the same material being tested or on known thickness values of the specimen.
- 5.4 **Couplant:** selection shall depend on chemical compatibility with the surface and the temperature of the specimen; refer to Appendix 2.

6 Calibration

- 6.1 The proper functioning of the examination system shall be checked and the equipment shall be calibrated by the use of the calibration standard at the beginning and end of each shift; every four (4) hours during the examination; when examination personnel are changed; when any equipment is changed; and at any time that malfunctioning is suspected.
 - 6.2 Calibration blocks shall be at ambient temperature during calibration. Calibration blocks shall **not** be cooled or heated for cryogenic or high temperature applications. A low viscosity couplant such as Ultragel II shall be used for calibration. High viscosity couplants are not acceptable for calibration but are usually required for high temperature measurements.
 - 6.3 The equipment shall be calibrated using a two-point calibration range that overlaps the expected measurement range, i.e., select a calibration block or step wedge thickness value greater than the maximum expected measurement value and a calibration block or step wedge value less than the expected measurement value.
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- 6.4 Apply couplant to the step wedge or calibration blocks and apply firm steady pressure to the transducer during calibration.
- 6.5 All calibration values shall be within ± 0.002 inch of the known thickness value.
- 6.6 If at the end of the shift the instrument has drifted more than 0.002 inches consideration should be given to retaking all of the measurements since the last calibration.
- 6.7 Button-type calibration blocks, on the front of some ultrasonic thickness gauges, shall not be used for calibration.

7 Examination

- 7.1 Surface Preparation.
 - 7.1.1 Discretion should be used when evaluating the cleaning requirements of each application, as many corrosion-monitoring applications require readings to be taken in the same condition, i.e., coated, as when originally measured.
 - 7.1.2 The test area shall be free of corrosion, insulation, weld spatter, surface irregularities, or foreign matter that might interfere with the examination. Remove as little metal as possible when cleaning.
 - 7.1.3 Where coatings interfere with the examination, the coating shall be removed and recorded.
 - 7.1.4 The extent, type, and data reporting needs of the examination shall be determined by the Plant or Unit inspector and communicated to the NDT examiner prior to the test.
- 7.2 Measurement
 - 7.2.1 Examinations shall be conducted from the OD surface or ID surface, as applicable.
 - 7.2.2 It is necessary that the examiner take into consideration the surface temperature of the component. If the surface temperature is below 32°F (0°C) or above 215°F (101°C), the surface temperature shall be measured and recorded.
 - 7.2.3 Apply couplant to the probe or the specimen surface.

Commentary Note:

For high-temperature measurements, couplant should always be applied to the face of the probe, not the hot part.

- 7.2.4 The transducer acoustic barrier shall be placed perpendicular to the center axis when taking measurements on pipe or round objects up to 24 inches in diameter. The acoustic barrier orientation is not important on pipe and round objects greater than 24 inches in diameter.
- 7.2.5 The transducer shall be held flat on the surface then slowly rocked tangentially after contact to find the lowest reading. All digital readings shall be verified by viewing the A-scan presentation on the instrument as doubling effects can give false readings on digital outputs. The lowest reading shall be recorded. For difficult readings, additional gain may be required to avoid grinding the transducer into the surface.
- 7.2.6 A valid reading is one that can be maintained on the gauge display for several seconds and the value is steady within ± 0.002 inch.
- 7.2.7 Thickness readings shall be measured and recorded to three decimal places.
- 7.2.8 Correction for the change in ultrasonic sound velocity in metal is not required within a thickness range of 0 to 1 inch. Temperature correction shall be performed for metal thickness greater than 1 inch for temperatures below 32°F and over 215°F. The following formula shall be used:

$$T_a = T_m \times [1.007 - (0.0001 \times \text{Temp})] \quad (1)$$

Where:

T_a = the actual thickness of the part

T_m = measured thickness of the part

Temp = surface temperature in °F

- 7.2.9 The transducer face shall be cleaned before each measurement at temperatures greater than 400°F as evaporated couplant can leave deposits on the transducer face.
- 7.2.10 Use the "touch test" to monitor the transducer temperature. If the transducer face is too hot to be held against your skin then it shall be cooled in air or water prior to taking readings.

8 Post Cleaning

All water based couplant shall be completely removed from the specimen, i.e., wiped with a dry absorbent cloth or paper towel, fresh water wash etc.

9 Records

9.1 A report of the examinations shall be made with the following information being identified and recorded. This shall be performed a minimum of once per day for typical OSI operations and shall include at least a), b), c), d), i), j), and l).

- a) Procedure
- b) Ultrasonic equipment
- c) Examination personnel identity
- d) Calibration sheet identity (if not on report form)
- e) Identification and location of material measured (OSI ID, etc.)
- f) Surface from which examination is conducted
- g) Map or record of measurements
- h) Date and time examinations were performed
- i) Couplant
- j) Calibration block identification
- k) Surface condition and temperature if required (see 7.2.2)
- l) Transducer frequency and diameter
- m) Special equipment

9.2 Calibration details, block identity, type and time of calibrations shall be recorded on a separate sheet if not provided in the report form.

Revision Summary

31 August, 2004

Revised the "Next Planned Update" and SC members.

Appendix 1 – Approved Ultrasonic Thickness Gauging Equipment List

(Contact Supervisor NDT Unit 874-6605 for updated list)

Manufacturer	Model Number(s)
Krautkramer	DMS, DMS 2, CL400 (with A-scan option only),
Panametrics	25DL Plus, 26DL Plus 36DL, 36DL Plus, 37DL Plus
Sonatest	Sonic 133 DL Plus, 1000S, 1200S, 1000HR, 1200HR,
	Alphaguage
NDT Systems	Eclipse TG2

Appendix 2 – Couplant Selection List

Ambient Temperature:	Oil, Cellulose, Ultragel II or equivalent
High Temperature:	Dow Corning 44M Grease - up to 450°F (232°C)
	Sonotech SONO 600 - up to 500°F (260°C)
	SONO 900 - up to 900°F (482°C)
	SONO 1100 - up to 1000°F (537°C)
	Krautkramer ZGM - up to 100°F (38°C)
	Hitempco - up to 550°F (287°C)
	Ultratherm - up to 1000°F (537°C)
Panametrics	F-2 - up to 540°F (282°C)
	G-2 - up to 600°F (315°C)