

ASNT QUESTIONS & ANSWERS BOOK

PHASED ARRAY ULTRASONIC TESTING

Levels II and III Review Questions
with Special Section on Full Matrix Capture



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The American Society for Nondestructive Testing Inc.



Documents

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ASNT Mission Statement:
ASNT exists to create a safer world by advancing scientific, engineering, and technical knowledge in the field of nondestructive testing.

ASNT Code of Ethics:
The ASNT Code of Ethics was developed to provide members of the Society with broad ethical statements to guide their professional lives. In spirit and in word, each ASNT member is responsible for knowing and adhering to the values and standards set forth in the Society's Code. More information, as well as the complete version of the Code of Ethics, can be found on ASNT's website, *asnt.org*.

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INTRODUCTION

Introduction

This book is a new entry into the *ASNT Questions & Answers Book* series. While most books in this series cover a testing method as recognized by Recommended Practice No. SNT-TC-1A, this book specifically focuses on the ultrasonic testing techniques phased array ultrasonic testing (PAUT) and full matrix capture (FMC). The questions have been prepared to align with the knowledge of technical principles needed for the qualification of nondestructive testing personnel in this technique as outlined in ANSI/ASNT CP-105-2020. Since CP-105 recommends that an Ultrasonic Testing Level II unrestricted certification be a prerequisite to study of the Phased Array Ultrasonic Testing and Full Matrix Capture topical outlines, the questions in this book also begin at Level II.

As with other books in the *ASNT Questions & Answers* series, this book is intended to provide candidates studying for qualifying examinations with sample Level II and III questions. It will help readers evaluate their knowledge of the principles of PAUT and FMC and determine if they possess the thorough understanding of the technique as recommended for qualification by CP-105. This book is also intended to provide sample questions for instructors and employers developing training programs utilizing PAUT and/or FMC.

Employers or other persons utilizing nondestructive testing services are cautioned that they retain full responsibility for ultimate determination of the qualifications of NDT personnel and for the certification process. The questions provided within this book should not serve as a qualifying examination.

Additional Information

Because ASNT is an International System of Units (SI) publisher, throughout the text both SI and imperial units are used.

In ASNT publications, the words *discontinuity* and *defect* have specific meanings. These words are used as follows:

- A *discontinuity* is an intentional (such as drilled holes) or unintentional interruption in the physical structure or

configuration of a material or component. NDT techniques reveal *indications* of discontinuities. Discontinuities may exist without being detected.

- A *defect* is a discontinuity whose size, shape, orientation, or location make it detrimental to the useful service of the object, or exceed accept/reject criteria of an applicable specification. Some discontinuities do not exceed an accept/reject criterion and are therefore not defects.
- The process for determining rejectability is *interpretation* or *evaluation*. All defects are discontinuities, but not all discontinuities are defects.

In 2018 ASNT accepted the ASTM E1316 definitions of calibration and standardization for use in its publications. These words are used as follows:

- *Calibration* is the comparison (which may include adjustment) of a test instrument to a known reference that is normally traceable to some recognized authority (for example, NIST). Calibration is typically performed by an organization considered qualified to do so (for example, an accredited laboratory or, in some cases, the instrument manufacturer) at a determined, periodic interval. Calibration of electronic instrumentation typically involves verification of the linearity of the instrument's response over its usable range.
- *Standardization* is typically completed prior to performing an NDT test, and may also be performed at times during the performance of the test and at the completion of the test as a validation of proper instrument operation. It is the adjustment of an NDT instrument using a reference standard (that contains a known condition) to obtain or establish a known and reproducible response.

REFERENCES

Recommended References

The following references were used in formulating the questions in this book.

Reference A

ASNT, 2007, *Nondestructive Testing Handbook, Vol. 7: Ultrasonic Testing*, third edition, The American Society for Nondestructive Testing, Columbus, OH.*

Reference B

ASNT, 2015, *Ultrasonic Classroom Training Book*, second edition, The American Society for Nondestructive Testing, Columbus, OH.*

Reference C

ASNT, 2016, *ASNT Level II Study Guide: Ultrasonic Testing Method*, third edition, The American Society for Nondestructive Testing, Columbus, OH.*

Reference D

ASNT, 2014, *ASNT Level III Study Guide: Ultrasonic Testing Method*, second edition with revisions, The American Society for Nondestructive Testing, Columbus, OH.*

Reference E

Dube, N., ed., 2004, *Introduction to Phased Array Ultrasonic Technology Application: R/T Tech Guideline*, Olympus NDT, Waltham, MA.

Reference F

Dube, N., 2007, *Advances in Phased Array Ultrasonic Technology Applications*, Olympus NDT, Waltham, MA.

Reference G

Olympus, 2010, *Phased Array Testing: Basic Theory for Industrial Applications*, Olympus NDT, Waltham, MA.†

Reference H

Eclipse Scientific, 2013, *Phased Array Ultrasonic Technology*, second edition, Eclipse Scientific, Owen Sound, Ontario, Canada.

Reference I

ASME, 2019, *ASME Boiler and Pressure Vessel Code, Section V: Nondestructive Examination, Article 4: Ultrasonic Examination Method for Welds*, Nonmandatory Appendix F: Examination of Welds Using Full Matrix Capture, The American Society of Mechanical Engineers, New York, NY.

Reference Codes

Each question found in this book is followed by letter(s) and page number(s) indicating the specific recommended reference where the answer may be found. For example:

4. The second critical angle occurs when:
- a. the transmitted longitudinal wave reaches 90°.
 - b. the incident longitudinal wave reaches 90°.
 - c. the refracted shear wave reaches 90°.
 - d. the reflected longitudinal wave reaches 90°.

C.5

In this example, the letter “C” refers to Reference C in the list above and “5” is the specific page in Reference C where the answer to the question is located.

Reference Usage

Reference A Total = 26

Phased Array Level II (5)
Full Matrix Capture (0)
Phased Array Level III (21)

Reference B Total = 20

Phased Array Level II (13)
Full Matrix Capture (2)
Phased Array Level III (5)

* Available from The American Society for Nondestructive Testing Inc.

† An updated version of the material from this book can be found in the Phased Array Tutorial available on Olympus's website, Olympus-ims.com

Reference C Total = 43

Phased Array Level II (29)
Full Matrix Capture (2)
Phased Array Level III (12)

Reference D Total = 13

Phased Array Level II (5)
Full Matrix Capture (2)
Phased Array Level III (6)

Reference E Total = 33

Phased Array Level II (10)
Full Matrix Capture (1)
Phased Array Level III (22)

Reference F Total = 51

Phased Array Level II (18)
Full Matrix Capture (1)
Phased Array Level III (32)

Reference G Total = 45

Phased Array Level II (14)
Full Matrix Capture (0)
Phased Array Level III (31)

Reference H Total = 18

Phased Array Level II (15)
Full Matrix Capture (0)
Phased Array Level III (3)

Reference I Total = 43

Phased Array Level II (0)
Full Matrix Capture (43)
Phased Array Level III (0)

PHASED ARRAY LEVEL II

Review Questions

1. Early through-transmission ultrasound-based techniques were less sensitive to:
 - a. joint geometry.
 - b. orientation of inspected part.
 - c. small defects and discontinuities.
 - d. the coupling medium used.

C.1
2. When supported, the transmitted and refracted shear wave is ____ with respect to the longitudinal wave:
 - a. twice the energy
 - b. at a lower refracted angle
 - c. at the same angle
 - d. at a greater refracted angle

C.6
3. The refracted beam angle is proportional in accordance with:
 - a. Snell's law, the incident angle, and relative sound speed between materials.
 - b. Snell's law, the incident angle, and the relative impedance between materials.
 - c. the diffraction equation and the relative sound speed between materials.
 - d. the diffraction equation and the relative impedance between materials.

C.5
4. The second critical angle occurs when:
 - a. the transmitted longitudinal wave reaches 90°.
 - b. the incident longitudinal wave reaches 90°.
 - c. the refracted shear wave reaches 90°.
 - d. the reflected longitudinal wave reaches 90°.

C.5
5. Waves that combine in phase reinforce each other, while waves that combine ____ will cancel each other.
 - a. out of phase
 - b. due to Lorentz force
 - c. at peak frequency
 - d. due to anisotropic effects

G.5-6
6. In order to facilitate beam steering and focusing, time delays (focal laws) are applied to:
 - a. both the transmission pulse and the acquisition signal.
 - b. the transmission pulse only.
 - c. the acquisition signal only.
 - d. neither the transmission pulse nor the acquisition signal.

E.10
7. The internal clock of a circuit is designed to:
 - a. coordinate the pulser, receivers, and other components to a common time.
 - b. generate a time stamp for acquired data.
 - c. keep time when the system is turned off.
 - d. not be used in most applications.

C.9
8. Which circuit triggers the pulser and sweep circuits in an A-scan display?
 - a. Receiver-amplifier.
 - b. Transducer.
 - c. Clock.
 - d. Damping.

C.9
9. The focal law generator takes into account:
 - a. the pitch and spacing of the probe, as well as the relative geometry and materials of the inspected part.
 - b. the element size of the probe, as well as the relative geometry of the part.
 - c. only the geometry of the part.
 - d. the pitch and spacing of the probe, as well as the materials of the inspected part.

C.61

10. External focal law generators can often produce higher quality images over onboard calculators because they:
 - a. are able to program the device using an ASCII file.
 - b. are able to be emailed.
 - c. use beam modeling software to improve inspection.
 - d. are more cost effective.

C.62
11. Which of the following definitions best represents the pitch of a phased array ultrasonic testing (PAUT) probe?
 - a. Element height or elevation.
 - b. Center-to-center distance between two successive elements.
 - c. Width of an individual element.
 - d. Center frequency.

F.76; G.23
12. While beam focusing and beam steering cannot be performed in the passive plane (axis), larger planar passive aperture will result in:
 - a. more shallow range focusing effect and narrower beam length.
 - b. more shallow range focusing effect and larger beam length.
 - c. deeper range focusing effect and narrower beam length.
 - d. deeper range focusing effect and larger beam length.

F.74
13. If the frequency of a phased array probe is doubled, the near-field length will:
 - a. decrease by a factor of two.
 - b. decrease by a factor of four.
 - c. increase by a factor of four.
 - d. increase by a factor of two.

F.74; G.15
14. For the same frequency, increasing the active aperture will:
 - a. increase unfocused beam spread and increase the near-field length.
 - b. increase unfocused beam spread and decrease the near-field length.
 - c. decrease unfocused beam spread and increase the near-field length.
 - d. decrease unfocused beam spread and decrease the near-field length.

G.12-16
15. Increasing the active aperture by using many small elements with small pitch will:
 - a. increase focusing factor and increase beam steering capability.
 - b. increase focusing factor and decrease beam steering capability.
 - c. create unwanted grating lobes.
 - d. create side lobes and decrease beam steering.

G.28
16. Grating lobes are a consequence of:
 - a. the periodic structure of a linear phased array.
 - b. the total active aperture of the phased array.
 - c. using a large passive aperture.
 - d. incorrect focal laws.

C.63
17. The backing material of a wedge is designed to:
 - a. minimize internal echoes within the wedge.
 - b. reduce coupling with the inspected part.
 - c. serve no purpose in the inspection.
 - d. allow for mounting to a scanner unit.

C.64
18. Mechanized scanners are chosen over manual scanners when:
 - a. operators cannot be trusted.
 - b. high scanning speeds are required.
 - c. a lower upfront cost is desired.
 - d. shear wave inspection is used.

C.65