

ASNT Level III Study Guide Basic

by
Matthew J. Golis



The American Society for Nondestructive Testing, Inc.

کتابخانه مرکزی
تاریخ: ۸۴/۴/۸۱
شماره: ۱۵۶۳



Published by
The American Society for Nondestructive Testing, Inc.
1711 Arlingate Lane
PO Box 28518
Columbus, OH 43228-0518

Copyright © 1997 by The American Society for Nondestructive Testing, Inc. ASNT is not responsible for the authenticity or accuracy of information herein. Published opinions and statements do not necessarily reflect the opinion of ASNT. Products or services that are advertised or mentioned do not carry the endorsement or recommendation of ASNT.

IRRSP, *Level III Study Guide, Materials Evaluation, NDT Handbook, Nondestructive Testing Handbook, The NDT Technician* and www.asnt.org are trademarks of The American Society for Nondestructive Testing, Inc. ACCP, ASNT, *Research in Nondestructive Evaluation* and *RNDE* are registered trademarks of The American Society for Nondestructive Testing, Inc.

ASNT exists to create a safer world by promoting the profession and technologies of nondestructive testing.

ISBN 1-57117-023-5

Printed in the United States of America

- first printing 06/87
- second printing 05/88
- third printing 10/89
- fourth printing 08/91
- fifth printing 01/94
- sixth printing with revision 08/97
- seventh printing 04/00
- eighth printing with revision 10/02
- ninth printing with revision 05/05

ASNT
 645, N.T.C.
 6/2/97

Contents

Foreword.....	7
Purpose	7
How to Use the Study Guide.....	7
Section 1, Administration of a Personnel Qualification and Certification Program.....	9
Chapter 1, Administration of a Personnel Qualification and Certification Program.....	11
Chapter 2, <i>Recommended Practice No. SNT-TC-1A</i>	13
History of <i>SNT-TC-1A</i>	13
Contents and Intended Uses of <i>SNT-TC-1A</i>	13
Overview of <i>SNT-TC-1A</i> , 1996.....	15
Analysis of <i>SNT-TC-1A</i> , Foreword.....	15
Excerpt from the Foreword.....	15
Analysis of <i>SNT-TC-1A</i> , Sections 1, 2, and 3.....	15
Excerpts from Sections 1, 2, and 3.....	15
Inquiries for <i>SNT-TC-1A</i> , Section 1.....	16
General Comments about <i>SNT-TC-1A</i> , Sections 2 and 3.....	18
Review Questions for <i>SNT-TC-1A</i> , Sections 1, 2, and 3.....	18
Analysis of <i>SNT-TC-1A</i> , Section 4.....	20
Excerpt from Section 4.....	20
Inquiries for <i>SNT-TC-1A</i> , Section 4.....	21
General Comments about <i>SNT-TC-1A</i> , Section 4.....	21
Review Questions for <i>SNT-TC-1A</i> , Section 4.....	21
Analysis of <i>SNT-TC-1A</i> , Section 5.....	23
Excerpt from Section 5.....	23
Review Questions for <i>SNT-TC-1A</i> , Section 5.....	23
Analysis of <i>SNT-TC-1A</i> , Section 6.....	24
Excerpt from Section 6.....	24
Inquiries for <i>SNT-TC-1A</i> , Section 6.....	24
General Comments about <i>SNT-TC-1A</i> , Section 6.....	28
Review Questions for <i>SNT-TC-1A</i> , Section 6.....	29
Analysis of <i>SNT-TC-1A</i> , Section 7.....	30
Excerpt from Section 7.....	30
Review Questions for <i>SNT-TC-1A</i> , Section 7.....	31
Analysis of <i>SNT-TC-1A</i> , Section 8.....	31
Excerpt from Section 8.....	31
Inquiries for <i>SNT-TC-1A</i> , Section 8.....	34
Review Questions for <i>SNT-TC-1A</i> , Section 8.....	35
Analysis of <i>SNT-TC-1A</i> , Section 9.....	37
Excerpt from Section 9.....	37
Inquiries for <i>SNT-TC-1A</i> , Section 9.....	37
General Comments about <i>SNT-TC-1A</i> , Section 9.....	39
Review Questions for <i>SNT-TC-1A</i> , Section 9.....	40
Analysis of <i>SNT-TC-1A</i> , Section 10.....	40
Excerpt from Section 10.....	40
Inquiries for <i>SNT-TC-1A</i> , Section 10.....	41
General Comments about <i>SNT-TC-1A</i> , Section 10.....	41
Review Questions for <i>SNT-TC-1A</i> , Section 10.....	42

Pre-1996 Editions of <i>SNT-TC-1A</i>	42
Inquiries for Pre-1996 Editions of <i>SNT-TC-1A</i>	42
Chapter 3, The ASNT Level III Certification Program.....	45
Status of the ASNT Level III Certification Program.....	45
What is an ASNT Level III?.....	45
ASNT Level III Examinations.....	46
Use of the ASNT Level III Certification.....	46
Certification Options.....	47
Recertification.....	47
Inquiries for ASNT Level III Certification.....	48
Review Questions.....	49
Chapter 4, ASNT CP-189 (1995).....	51
Overview of ASNT CP-189.....	51
Review Questions.....	55
Section 2, General Application of Various NDT Methods.....	57
Chapter 5, General Applications of Various NDT Methods.....	59
ASNT Basic Examination.....	59
Topical Outlines, Reference Resources and Review Questions.....	59
Acoustic Emission Testing (AE).....	59
Topical Outline.....	59
Reference.....	59
Review Questions.....	60
Eddy Current Testing (ET).....	60
Topical Outline.....	60
Reference.....	61
Review Questions.....	61
Infrared/Thermal Testing (IR).....	64
Topical Outline.....	64
Reference.....	64
Review Questions.....	64
Leak Testing (LT).....	67
Topical Outline.....	67
References.....	67
Review Questions.....	67
Liquid Penetrant Testing (PT).....	68
Topical Outline.....	68
Reference.....	68
Review Questions.....	68
Magnetic Particle Testing (MT).....	71
Topical Outline.....	71
Reference.....	72
Review Questions.....	72
Neutron Radiographic Testing (NR).....	74
Topical Outline.....	74
Reference.....	74
Review Questions.....	74
Radiographic Testing (RT).....	77
Topical Outline.....	77
Reference.....	78
Review Questions.....	78
Ultrasonic Testing (UT).....	81
Topical Outline.....	81
Reference.....	82
Review Questions.....	82

Vibration and Analysis Testing (VA)	86
Topical Outline	86
References	86
Review Questions	87
Visual and Optical Testing (VT)	87
Topical Outline	87
References	87
Review Questions	87
Section 3, Materials and Processes for NDT Technology	91
Chapter 6. Materials and Processes for NDT Technology	93
Overview of <i>Materials and Processes For NDT Technology</i>	93
Review Questions	94
<i>Materials and Processes for NDT Technology</i> , Chapter 1	94
<i>Materials and Processes for NDT Technology</i> , Chapter 2	95
<i>Materials and Processes for NDT Technology</i> , Chapter 3	96
<i>Materials and Processes for NDT Technology</i> , Chapter 4	97
<i>Materials and Processes for NDT Technology</i> , Chapter 5	99
<i>Materials and Processes for NDT Technology</i> , Chapter 6	100
<i>Materials and Processes for NDT Technology</i> , Chapter 7	101
<i>Materials and Processes for NDT Technology</i> , Chapter 8	102
<i>Materials and Processes for NDT Technology</i> , Chapter 9	104
<i>Materials and Processes for NDT Technology</i> , Chapter 10	105
<i>Materials and Processes for NDT Technology</i> , Chapter 11	109
<i>Materials and Processes for NDT Technology</i> , Chapter 12	110
<i>Materials and Processes for NDT Technology</i> , Chapter 13	111
<i>Materials and Processes for NDT Technology</i> , Chapter 14	112
<i>Materials and Processes for NDT Technology</i> , Chapter 15	113
<i>Materials and Processes for NDT Technology</i> , Chapter 16	115
<i>Materials and Processes for NDT Technology</i> , Chapter 17	116
Answers to Review Questions	119
Appendix 1, Code of Ethics for Level III NDT Personnel Certified by ASNT	123
Index	127

Foreword

Purpose

This study guide is intended to aid individuals preparing to take the Basic Examination as part of the process of becoming certified as an ASNT NDT Level III in one or more NDT methods. It is equally useful for persons preparing to take a Basic Level III Examination under an employer's personnel qualification and certification (PQ&C) program per *SNT-TC-1A*.

The material in this study guide addresses the body of knowledge included in the Basic Examination administered under the ASNT NDT Level III certification program. The ASNT NDT Level III certification program is a service, offered by the American Society for Nondestructive Testing, Inc., that gives inspection personnel an opportunity to have their familiarity with the principles and practices of NDT assessed by an independent body. The program uses an independent body to review credentials and uses comprehensive written examinations to identify those persons who meet the criteria for becoming an ASNT NDT Level III for each NDT method. Method examinations are offered in:

1. Acoustic emission testing (AE)
2. Electromagnetic testing (ET)
3. Infrared/Thermal testing (IR)
4. Leak testing (LT)
5. Liquid penetrant testing (PT)
6. Magnetic particle testing (MT)
7. Neutron radiographic testing (NR)
8. Radiographic testing (RT)
9. Ultrasonic testing (UT)
10. Vibration analysis testing (VA)
11. Visual and optical testing (VT)

The ASNT NDT Level III certification program requires satisfactory completion of a 4-hour Basic Examination. Ten different methods examinations are given with durations of 2-4 hours, depending upon each method's complexity. To be eligible to take the ASNT NDT Level III examinations, persons must

qualify by virtue of their documented education and experience.

The Basic Examination covers:

1. the administration of personnel qualification and certification programs (based on the most recent issuance of *SNT-TC-1A* and *ASNT CP-189*),
2. general principles and applications of common NDT methods, and
3. basic materials and technology processes.

Each Method Examination covers:

1. fundamentals and principles,
2. techniques and applications, and
3. procedures interpretation.

How to Use the Study Guide

Each section of this study guide begins with a discussion of the topical material, followed by a list of technical literature references and a set of representative multiple-choice questions covering both the material in the study guide and information taken from the cited references.

The user should read through the text of the study guide and if the discussion covers unfamiliar material, the referenced selections should also be read and studied. Finally, the questions at the end of each section should be answered. Success in answering the questions will help the user to determine the need for more or less concentrated study in particular detailed areas. Persons who are familiar with some of the topics may wish to go directly to the questions. If they can be answered confidently and correctly, reading the material may be optional.

This study guide is designed to assist individuals in their preparation for the ASNT NDT Level III Basic Examination. It is not intended to be their only source of preparation. The study guide provides a general overview of

subject matter covered by the examination so that students can identify those areas of the body of knowledge in which they need further study.

Note that references to persons who have met the criteria for the Level III certifications issued by ASNT are called ASNT NDT

Level III. This is in contrast to the person who has met the criteria of their employer and who are identified as the employer's Level III or just Level III.

Section 1

Section 1

Section 1

Administration of a Personnel Qualification and Certification Program

References

Recommended Practice No. SNT-TC-1A, 1996 Edition. Columbus, OH: The American Society for Nondestructive Testing, Inc. 1996.*

ASNT CP-189 (1995), ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel, 1995 Edition. Columbus, OH: The American Society for Nondestructive Testing, Inc. 1996.*

*This reference is available from ASNT.

Chapter 1

Administration of a Personnel Qualification and Certification Program

Qualification and certification of NDT personnel, based on some standardized approach that is recognized and agreed to by buyers and sellers of NDT-related inspections, is widely practiced throughout industry. *Recommended Practice No. SNT-TC-1A, Personnel Qualification and Certification in Nondestructive Testing* was the first document widely used for this purpose. Another document initially issued by ASNT in March 1991 and reissued in December 1995 is *ASNT CP-189, ASNT Standard for Qualification and Certification of Nondestructive Testing Personnel*. This document is different from *SNT-TC-1A* in that it is an ANSI Standard and it contains a minimal set of clearly defined requirements that must be satisfied in their entirety. The Basic Examination of the ASNT NDT Level III certification program addresses the most recent editions of both of these documents.

SNT-TC-1A, 1996 Edition and *ASNT CP-189 (1995)*, will be analyzed paragraph-by-paragraph in the following sections. Selected inquiries and responses taken from published interpretations offered by the *SNT-TC-1A* Interpretation Panel are included to assist individuals understand some of *SNT-TC-1A*'s philosophical intentions. The responses should be considered as clarifications of intent of the recommended practice. The inquiries and responses are verbatim the way they were written in the year indicated in the inquiry number. They do not address subsequent changes made to later editions of *SNT-TC-1A*. No such interpretations have been published for *CP-189*.

The general structure and some of the details of the ASNT NDT Level III certification program and how it supports the manner in which *SNT-TC-1A* and *CP-189* are implemented throughout industry are also covered in Chapter 3.

Chapter 2

Recommended Practice No. SNT-TC-1A

History of SNT-TC-1A

The reasons for which *SNT-TC-1A* was created and the manner in which it evolved were described in an article published in *Materials Evaluation*, October 1968, Vol. 26, No. 10, pages 12A-14A, by Harold Hovland and Carl B. Shaw, titled, "How to Qualify and Certify NDT Personnel." The following excerpts outline how this important recommended practice came into existence.

With the increasing complexity and number of nondestructive test methods in use and with greater reliance upon nondestructive testing, industry has not been able to recruit and train personnel in large enough numbers and in a timely fashion to fill the need. Many customers found that they were not receiving the nondestructive test examinations they felt they had paid to receive.

Large segments of the economy, such as the Government and prime contractors, found it expedient to put the responsibility for the training and qualification and verification of the qualifications of nondestructive test personnel upon the manufacturer. This resulted in the generation of a number of documents dealing with the question of the training, qualification, and certification of nondestructive test personnel. Although these documents all pertain to the same subject and have the same objective, in their details they were often conflicting, thereby causing undue cost to American industry.

Beginning about 1959, a few corporations, government agencies, and other technical societies inquired of ASNT as to whether the training and qualification of nondestructive test personnel was properly the domain of the Society.

In 1961, the Society, through its Technical Council, assigned a Task Group to study the feasibility of preparing a document that would deal with the training requirements and the documentation thereof for the qualification of

nondestructive test personnel ... the Task Group endeavored to prepare a recommended practice which could contain the consensus of expert opinion regarding the training of personnel and an average of requirements for formal education, time for on-the-job training, and documentation.

The resulting *SNT-TC-1A* is a recommended practice for the qualification and certification of nondestructive test personnel. It provides a format which industry can follow in writing an individualized procedure for the qualification and certification of personnel which meets the needs and requirements unique to each segment of industry.

Contents and Intended Uses of SNT-TC-1A

The following information has been excerpted from the same article cited above. The text of this article has been modified to include changes made in subsequent editions of *SNT-TC-1A*.

It is intended that *SNT-TC-1A* serve as a guide for each employer user in preparing their specific personnel qualification and certification document (procedure or written practice).

SNT-TC-1A sets forth a scope and definitions, it lists the test methods, and it explains the various levels of qualifications. The primary document also details the manner in which personnel are examined and certified. The question arises, 'how do I document certification in my particular procedure?' The point to remember here is that the procedure as written by any user of this document must satisfy the requirements of their company and must be acceptable to the company's customers. Within this context, certification may take any one of several forms. It may consist merely of the records of the training programs and the examinations and the grades of the

examinations. It may require a certificate that states explicitly that a particular person is qualified to a given level for a specific method. It may take the form of a card upon which an employer certifies the level of training and qualification of its personnel.

The employer has the same responsibility for the qualification and certification of its NDT personnel as it has for the product. For example, even though an employer may purchase a complete product and sell this product under the company's own name, the employer still bears full responsibility to the customer for the quality of that product and for the product being what the company purports it to be. The employer may elect to purchase components and assemble them and sell the result as a complete product; then again, the employer may manufacture all components of the product. In any of these cases, the employer bears a certain responsibility. The employer is responsible that what is being sold is indeed what it is claimed to be, that it will meet certain requirements of quality, that it will not harm the user, and that it will not destroy the user's property.

The employer may choose to exercise any of these prerogatives in the training, qualification, and certification of its personnel. The company may employ persons previously trained and certify these people; however, the responsibility would be the same as if they had been trained and qualified by the employer. Ideally the employer will conduct a training program as recommended in the documents, will examine these persons, and will certify as to their qualification to do the work. The employer will exercise this responsibility through a person in the organization who is qualified as a Level III, and who is qualified to train or provide the training of the personnel under them and to exercise judgment as to the qualification of these personnel.

From a factual point of view, very few employers using nondestructive testing persons will conform exactly to all the specific recommendations outlined in the document. Deviation from the recommendations of *SNT-TC-1A* should be documented in the employer's written practice. A recommended outline is provided for training programs in each of the NDT methods. The employer may elect to send its employees to a school or short course to receive these. The employer may elect to

write its own training program and conduct it at its own facilities. Again, as was stated with regard to certification, the responsibility for the adequacy of the training course content lies with the employer.

Representative examination questions are available from the Society. Each question cites the training reference used to identify the correct answer. It is intended that a qualified Level III use selected questions comparable to those found on these lists to examine inspection personnel to be sure they understand the training material. The Level III may decide to reword the questions or to substitute questions. In addition to the general examination, a specific written examination is required. It is intended that the specific examination reflect the equipment that is used by the employee being examined, that it reflect the requirements of the procedures normally used by the employer, and that it satisfy the specific requirements of any customer of the employer.

A Practical Examination is also necessary. The Practical Examination is primarily a hands-on test and an examination to determine that the examinee understands and knows how to use the written procedures and the equipment. Test objects should be representative of those that the inspector will most likely encounter. Critical points of reference should be predetermined for which the examinee will be graded in their Practical Examination. This may include such things as close adherence to the procedure, action taken when the procedure cannot be followed, handling of the parts being tested, interpretation of test results, disposition and the manner in which a report is written.

Note the emphasis in the foregoing text on the intent that *SNT-TC-1A* should be used as a guideline, not as a fixed requirement. This is reaffirmed on the front cover of *SNT-TC-1A* where the following statement is found:

This document is intended as a guideline for employers to establish their own written practice for the qualification and certification of their NDT Personnel. It is not intended to be used as a strict specification.

Overview of SNT-TC-1A, 1996

This section provides a paragraph-by-paragraph overview of *SNT-TC-1A* including excerpts from the document (in quotations and a different font), popular inquiries and official responses provided by the ASNT Interpretation Panel, general comments by the author, and review questions. The *SNT-TC-1A* Interpretation Panel Chairman is the Chairman of the Personnel Qualification (PQ) Division and the Vice-Chairman of the Interpretation Panel is the Vice-Chairman of the PQ Division. The membership consists of a representative of the Technical Council, a representative of the Certification Management Board, the E&Q Council officers, PQ Division Committee Chairman (if pertaining to the specific method), a representative of the Standards Development Committee, and the Secretary of the PQ Division.

Analysis of SNT-TC-1A, Foreword

Excerpt from the Foreword

The *Foreword* of *SNT-TC-1A* appears on the first page inside the front cover and states:

This recommended practice establishes the general framework for a qualification and certification program. In addition, the document provides recommended educational, experience, and training requirements for the different test methods. Supplementary documents include question and answer lists which may be used in composing examinations for nondestructive testing personnel.

This recommended practice is not intended to be used as a strict specification. It is recognized, however, that contracts require programs which meet the intent of this document. For such contracts, acceptability of an employer's program must be agreed upon by purchaser and supplier.

The verb "should" has been used throughout this document to emphasize the recommendation presented herein. It is the employer's responsibility to address specific needs and to modify these guidelines as appropriate in a written practice. In the employer's written practice, the verb "shall" is to be used in place of "should" to emphasize the employer's needs.

Analysis of SNT-TC-1A, Sections 1, 2, and 3

Excerpts from Sections 1, 2, and 3

1. Scope

- 1.1 It is recognized that the effectiveness of nondestructive testing (NDT) applications depends upon the capabilities of the persons who are responsible for, and perform, nondestructive testing. This Recommended Practice has been prepared to establish guidelines for the qualification and certification of nondestructive testing personnel whose specific jobs require appropriate knowledge of the technical principles underlying the nondestructive tests they perform, witness, monitor, or evaluate.
- 1.2 This document provides guidelines for the establishment of a qualification and certification program.
- 1.3 These guidelines have been developed by the American Society for Nondestructive Testing to aid employers in recognizing the essential factors to be considered in qualifying employees engaged in any of the test methods listed in Section 3.
- 1.4 It is recognized that these guidelines may not be appropriate for certain employers' circumstances and/or applications. In developing a written practice as required in Section 5, the employer should review the detailed recommendations presented herein and modify them, as necessary, to meet particular needs.

2. Definitions

- 2.1 Terms included in this document are defined as follows:
 1. Certification: written testimony of qualification.
 2. Certifying Authority: the person or persons properly designated in the written practice to sign certifications on behalf of the employer.
 3. Certifying Agency: the employer of the personnel being certified.
 4. Closed-book Examination: an examination administered without access to reference material except for materials supplied with or in the examination.

5. **Comparable:** being at an equivalent or similar level of NDT responsibility and difficulty as determined by the employer's Level III.
6. **Documented:** the condition of being in written form.
7. **Employer:** the corporate, private, or public entity which employs personnel for wages, salary, fees, or other considerations.
8. **Experience:** work activities accomplished in a specific NDT method under the direction of qualified supervision including the performance of the NDT method and related activities but not including time spent in organized training programs.
9. **Outside Agency:** a company or individual who provides NDT Level III services and whose qualifications to provide these services have been reviewed by the employer engaging the company or individual.
10. **Qualification:** demonstrated skill, demonstrated knowledge, documented training, and documented experience required for personnel to properly perform the duties of a specific job.
11. **Recommended Practice:** a set of guidelines to assist the employer in developing uniform procedures for the qualification and certification of NDT personnel to satisfy the employer's specific requirements.
12. **Training:** the organized program developed to impart the knowledge and skills necessary for qualification.

3. Nondestructive Test Methods

- 3.1 Qualification and certification of NDT personnel in accordance with this Recommended Practice is applicable to each of the following methods:
 1. Acoustic Emission Testing (AE)
 2. Electromagnetic Testing (ET)
 3. Leak Testing (LT)
 4. Liquid Penetrant Testing (PT)
 5. Magnetic Particle Testing (MT)
 6. Neutron Radiographic Testing (NR)
 7. Radiographic Testing (RT)
 8. Infrared/Thermal Testing (IR)
 9. Ultrasonic Testing (UT)
 10. Vibration Analysis Testing (VA)
 11. Visual and Optical Testing (VT)

Inquiries for *SNT-TC-1A*, Section 1

NOTE: The responses of the *SNT-TC-1A* Interpretation Panel are subject to the statement in the Scope of *SNT-TC-1A*, paragraph 1.4, "It is recognized that these guidelines may not be appropriate for certain employers' circumstances and/or applications. In developing a written practice as required in section 5, the employer should review the detailed recommendations presented herein and shall modify them, as necessary, to meet particular needs." The inquiries must be stated in general terms only, because the Interpretation Panel cannot serve as a referee between a buyer and seller or otherwise become involved in any specific case. Inquiries are numbered to include the year of the inquiry and always refer to the edition of *SNT-TC-1A* in effect in that year, unless otherwise stated in the question. *SNT-TC-1A* was published in these years: 1968, 1975, 1980, 1984, 1988, 1992, 1996, 2001.

1. Inquiry 76-4

In paragraph 1.1, note the statement regarding "personnel whose specific jobs require appropriate knowledge of ... the nondestructive tests they perform, witness, monitor, or evaluate." The *SNT-TC-1A* Interpretation Panel acted on the following inquiry about this section.

Inquiry:

Paragraph 1.1 of *SNT-TC-1A* refers to individuals who "perform, witness, monitor, or evaluate" nondestructive tests. Is it intended that individuals whose principal functions are to witness, monitor, or evaluate nondestructive tests be qualified in the same manner as those whose principal function is to perform nondestructive tests?

Response:

It is intended that the employer designate through the written practice specific jobs that require knowledge of the technical principles of nondestructive testing. The employer should test the statement of paragraph 1.1, "... personnel whose specific jobs require appropriate knowledge of the technical principles underlying the nondestructive tests they perform, witness, monitor, or evaluate," against the specific job elements of the personnel in question in order to establish

whether or not the specific job requires knowledge of nondestructive testing.

2. Inquiry 80-8

Paragraph 1.4 very clearly states the intent that the detailed recommendations of *SNT-TC-1A* should be reviewed and modified by the user to satisfy unique needs. This allowance was originally incorporated in recognition of the fact that each manufacturer or each service organization has a different clientele. Customer or clientele requirements ultimately determine what is acceptable between buyer and seller, even to the details of qualifying NDT personnel. An inquiry related to this is as follows:

Inquiry:

Is our company's specific written practice acceptable?

Response:

It is against ASNT policy to judge the applicability of company documents. As a general comment, it is the employer's prerogative to establish criteria for certification. It is then the customer's prerogative to accept or reject those criteria.

3. Inquiry 78-7

ASNT has received frequent inquiries from a variety of sources regarding mandatory imposition of the recommendations of *SNT-TC-1A* into firm and inflexible requirements. By design, this document lists recommendations which are intended to be used selectively in support of the individual needs of each employer. However, due in part to such requests for some type of mandatory requirements document, *ASNT-CP-189* was developed as a Standards document that establishes the minimum requirements for the qualification and certification of NDT personnel. ASNT always intended that the recommendations of *SNT-TC-1A* be applied with flexibility and reason, recognizing that business enterprises often may need to satisfy differing customer requirements.

Inquiry:

1. Should personnel who operate (ultrasonic) digital thickness measurement equipment be qualified and certified?

2. To what Level should such personnel be certified?
3. Does ASNT anticipate a change in *SNT-TC-1A* that would provide specific recommendations for qualifying and certifying such personnel?

Response:

1. Whether any NDT personnel should be certified depends solely upon the needs of the employer and the requirements of the employer's customers or clientele.
2. Likewise, the Level to which personnel should be certified depends upon the same factors as in 1., above. Note that paragraph 4.1 of *SNT-TC-1A* provides for subdivision within the Levels as needed.
3. Paragraph 1.4 and paragraph 4.1 of *SNT-TC-1A* are intended to provide the employer with adequate flexibility to accommodate a variety of special needs as documented in the written practice. While the Recommended Training Course Outline of *SNT-TC-1A* does not specifically address digital thickness measurement, the principles of pulse-echo techniques are those involved. The training course outline does provide for instruction in the employer's specific equipment uses, and, as with the remainder of *SNT-TC-1A*, the training course outline should be modified if necessary to meet employers' specific needs.

4. Inquiries 80-4 and 80-8

Two other inquiries pertaining to this concept. Both inquiries have the same response.

Inquiry (80-4):

NDT examiners in our employ who perform examinations using liquid penetrant use only the visible dye, solvent-removable, penetrant technique. Since our examiners do not have need to be qualified in the other liquid penetrant techniques, is it permissible to modify the number of general and specific questions as well as the hours of training and work experience to satisfy requirements of *SNT-TC-1A* for Level I and Level II examiners?

Inquiry (80-8):

May an employer deviate from the guidelines to meet his specific needs?

Response:

The answer to both of these questions is: Yes, in accordance with paragraph 1.4 of *SNT-TC-1A*, the employer should modify the guidelines to meet his needs.

General Comments about *SNT-TC-1A*, Sections 2 and 3

In section 2, *Definitions*, each of these terms should be carefully studied. Some do not clearly understand the difference between qualification and certification. Considering each term as representing a process, the process of qualifying personnel involves assessment of the adequacy of the skills, training, and experience of personnel being considered for certain tasks. The process of qualifying may require that education and training be imparted on such personnel. Assessment of qualifications often requires that the personnel be examined. Following the process of qualification, individuals meeting or exceeding the minimum qualification requirements of the employer can be certified. That is, the employer provides evidence that a qualifying process was followed. Such evidence backs up the employer's assertion that certain individuals are qualified to perform certain critical functions and is the employer's "certification" that the evidence of qualification exists.

Fundamental in free enterprise is the tenet that producers of goods and suppliers of services are ultimately responsible for the quality and effectiveness of such goods and services as well as bearing responsibility for shortcomings and failures. Therefore, regardless of the details of the processes by which individuals became qualified, the direct employer of the personnel being certified must bear the end responsibility for conferring a certification and, thereby, can be the only "certifying agency." Such absolute responsibility does not preclude the use of outside services by employers to assist in imparting and/or assessing qualifications of individuals being certified. The use of outside services does not relieve the employer from responsibility, nor can the employer abrogate or delegate this responsibility to an outside agency.

SNT-TC-1A has been referenced by certain codes and specifications to be used, in effect, as a model for employers to develop a written practice concerning some method of NDT not currently covered in *SNT-TC-1A*.

Review Questions for *SNT-TC-1A*, Sections 1, 2, and 3

Based on the foregoing discussion, answer the following questions relating to *SNT-TC-1A* and the administration of a qualification and certification program in NDT.

- Q.1-1 Which of the following statements is true concerning the usage of *SNT-TC-1A*?
- SNT-TC-1A* is intended for use by a limited set of industrial segments.
 - SNT-TC-1A* was generated to satisfy the specification requirements of ASME.
 - SNT-TC-1A* was last revised in 1988.
 - SNT-TC-1A* is not intended to be used as a strict specification.
- Q.1-2 The *SNT-TC-1A* Interpretation Panel will respond to inquiries about *SNT-TC-1A*. The inquiry must be:
- written and stated in general terms.
 - written including specific details of the case, e.g., names, places, dates, and other pertinent facts.
 - considered by the ASNT Board of Directors if it involves decisions that would place ASNT in a position between buyer and seller.
 - ruled upon by the Technical Council of ASNT before the *SNT-TC-1A* Interpretation Panel prepares a response.

- Q.1-3 Which of the following statements is true?
- ASNT has been providing certification examinations for Level III personnel since the late 1960s.
 - SNT-TC-1A* was first published in the late 1960s.
 - SNT-TC-1A* requires that Level III personnel be qualified and certified by ASNT.
 - SNT-TC-1A* was developed to satisfy requirements for NDT personnel qualification and certification set forth in parts of the *ASME Boiler and Pressure Vessel Code*.
 - All of the above are true.
- Q.1-4 With regard to the training of NDT personnel, the employer:
- must conduct all of the training on the premises.
 - may engage an outside service who must conduct the training on the employer's premises.
 - should not conduct the training, being too close to company's problems.
 - may engage an outside service but is nevertheless responsible for the certification of the company's NDT personnel.
- Q.1-5 *SNT-TC-1A* is intended as a guideline for employers:
- to establish their own written practice that must be used as a strict specification.
 - to establish their own written practice for the qualification and certification of their NDT personnel.
 - to define training course requirements for contractors performing outside training services.
 - who are corporate members of ASNT.
 - to impose upon their suppliers as a mandatory requirement.
- Q.1-6 The following is a statement in *SNT-TC-1A*, "It is recognized that these guidelines may not be appropriate for certain employers' circumstances and/or applications." What should be done if the guidelines are not appropriate?
- The employer must change its operations to conform to the guidelines.
 - The employer must seek relief from ASNT for inappropriate applications.
 - The employer should review the detailed recommendations and modify them, as necessary, to meet its particular needs.
 - The employer shall submit an inquiry in writing directed to the *SNT-TC-1A* Interpretation Panel.
- Q.1-7 Which of the following statements is not true?
- Certification is written testimony of qualification.
 - Qualification is the skill, training, and experience required for personnel to properly perform the duties of a specific job.
 - The employer is the corporate or private entity that employs personnel for wages or salary.
 - A certifying agency is any organization used by an employer in training NDT personnel.
 - Training is a program developed to impart the knowledge and skills necessary for qualification.
- Q.1-8 Who should be responsible to assess whether or not an individual should be qualified and certified who does not perform NDT but monitors and evaluates NDT?
- ASNT.
 - The individual's employer.
 - A government regulatory agency.
 - The customer's auditor.
 - None of the above.

Q.1-9 To which of the following NDT methods is *SNT-TC-1A* currently not applicable?

- Visual and optical testing.
- Infrared/Thermal testing.
- Acoustic emission testing.
- Electromagnetic testing.
- Holographic testing.

Q.1-10 ASNT intended that the recommendations of *SNT-TC-1A* be applied:

- with flexibility and reason.
- precisely as written.
- as minimum requirements.
- as maximum requirements.
- only when work is being done in accordance with a code or specification.

Q.1-11 Of the following, which is most appropriate to determine the needs to qualify and certify personnel whose only NDT function is to operate digital thickness equipment?

- ASNT.
- ASME.
- The employer.
- The customer.
- None of the above.

Q.1-12 Certification is:

- the skill, training, and experience required for personnel to properly perform the duties of a specific job.
- written testimony of qualification.
- intended to be conferred by an organization independent from the employer.
- intended to be conferred by an organization hired by the employer.
- intended to be conferred by ASNT NDT Level III personnel only.

Q.1-13 Use of *SNT-TC-1A* is mandatory when:

- the material being tested is for a U.S. Air Force contract.
- the material being tested is for a U.S. Navy contract.
- it has been specified by the customer.
- the material being tested is for a U.S. Army contract which requires certification of NDT personnel.
- any of the above cases occurs.

Analysis of *SNT-TC-1A*, Section 4

Excerpt from Section 4

4. Levels of Qualification

4.1 There are three basic levels of qualification. These levels may be further subdivided by the employer for situations where additional levels are deemed necessary for specific skills and responsibilities.

4.2 While in the process of being initially trained, qualified, and certified, an individual should be considered a trainee. A trainee should work with a certified individual. A trainee shall not independently conduct, interpret, evaluate or report the results of any NDT.

4.3 The three basic levels of qualification are as follows:

1. NDT Level I — An NDT Level I individual should be qualified to properly perform specific calibrations, specific NDT, and specific evaluations for acceptance or rejection determinations according to written instructions and to record results. The NDT Level I should receive the necessary instruction or supervision from a certified NDT Level II or III individual.
2. NDT Level II — An NDT Level II individual should be qualified to set up and calibrate equipment and to interpret and evaluate results with respect to applicable codes, standards, and specifications. The NDT Level II should be thoroughly familiar with the scope and limitations of the methods for which qualified and should exercise assigned responsibility for on-the-job training and guidance of trainees and

- NDT Level I personnel. The NDT Level II should be able to organize and report the results of NDT.
3. NDT Level III — An NDT Level III individual should be capable of establishing techniques and procedures; interpreting codes, standards, specifications, and procedures; and designating the particular NDT methods, techniques, and procedures to be used. The NDT Level III should be responsible for the NDT operations for which qualified and assigned and should be capable of interpreting and evaluating results in terms of existing codes, standards, and specifications. The NDT Level III should have sufficient practical background in applicable materials, fabrication, and product technology to establish techniques and to assist in establishing acceptance criteria where none are otherwise available. The NDT Level III should have general familiarity with other appropriate NDT methods, as demonstrated by the ASNT NDT Level III Basic examination or other means. The NDT Level III, in the methods in which certified, should be capable of training and examining NDT Level I and Level II personnel for certification in those methods.

Inquiries for *SNT-TC-1A*, Section 4

Several inquiries have been handled by the *SNT-TC-1A* Interpretation Panel regarding section 4. **NOTE:** Inquiries are numbered to include the year of the inquiry and always refer to the edition of *SNT-TC-1A* in effect in that year, unless otherwise stated in the question. *SNT-TC-1A* was published in these years: 1968, 1975, 1980, 1984, 1988, 1992, 1996, 2001.

1. Inquiry 76-3

Inquiry:

Is it the intent of *SNT-TC-1A* that the Level I NDT persons described in paragraph 4.3(a) of the 1975 Edition of this document be the same as the Level I individual described in the *SNT-TC-1A* (1968 Edition) paragraph 4.1(a) with both having the same capabilities?

Response:

Yes. The changes in wording between the 1975 and the 1968 versions of *SNT-TC-1A*, insofar as the duties and capabilities of Level I personnel are concerned, were intended only to clarify the intent of the document. None of these changes in wording were intended as substantive changes.

Note: As versions of *SNT-TC-1A* change, the old is replaced by the newer version with corrections to be addressed at recertification time. See Inquiries 78-2, 80-14 and 85-2.

2. Inquiry 76-5

Inquiry:

In accordance with *SNT-TC-1A* (1975 Edition), may a Level I NDT person who has been trained, qualified, and certified in accordance with *SNT-TC-1A* (1975 Edition) be the sole person to perform, evaluate, and sign for final acceptance of NDT examinations in accordance with written procedures and acceptance standards with occasional surveillance and guidance from a Level II or III?

Response:

Yes. The intent in *SNT-TC-1A* is that the Level I person may perform the above functions provided they are in accordance with written procedures and so documented in the employer's written practice.

3. Inquiry 78-9

Inquiry:

Is it intended that personnel currently certified as NDT Level III within the guidelines of *SNT-TC-1A* who also regularly perform Level II functions be qualified as recommended in paragraphs 8.2, 8.5.2, 8.6, and 9.7?

Response:

It is the opinion of the Interpretation Panel that personnel currently certified as Level III may regularly perform Level II functions without specifically being qualified as Level II as recommended in paragraph 8.2, 8.5.2, and 8.6 of *SNT-TC-1A*. However, as recommended in paragraph 9.7, all levels should be periodically recertified.

General Comments about *SNT-TC-IA*, Section 4

Implicit in the definitions of Level I, Level II, and Level III as outlined in paragraph 4.3.1, 4.3.2, and 4.3.3 is the concept that the qualifications for Level III equal and exceed those of Level II. The employer must be satisfied with the proficiency of any individual at any Level to handle work tasks. *SNT-TC-IA* is not intended for use to determine an individual's proficiency. It is intended as a guideline to establish qualifications.

Review Questions for *SNT-TC-IA*, Section 4

- Q.1-14 The basic levels of qualification recommended by *SNT-TC-IA* are:
- Trainee, Level I, Level II, Level III.
 - Trainee, Apprentice, Level I, Level II, Level III.
 - Level I, Level II, Level III.
 - none of the above.
- Q.1-15 Should personnel that operate ultrasonic digital thickness measurement equipment be qualified and certified?
- Yes, because *SNT-TC-IA* requires that all personnel performing NDT be qualified and certified.
 - No, because *SNT-TC-IA* does not cover that specific operation.
 - Only if required by industry codes, standards, and specifications.
 - Whether any NDT personnel should be qualified and certified depends solely upon the needs of the employer and the requirements of the employer's customers or clientele.
- Q.1-16 According to the recommendations of *SNT-TC-IA*, which of the following is true concerning a Trainee's activities?
- The Trainee may not conduct nondestructive tests independently, and may not report test results.
 - The Trainee may not conduct nondestructive tests independently, but may interpret test results if acting under written instructions.
 - The Trainee should work along with a certified individual, and may be considered a Level I, provided that the certified individual co-signs any test reports.
 - The Trainee should work along with a certified individual and may perform any activities as directed by the certified individual.
 - Trainees are not covered in *SNT-TC-IA*.
- Q.1-17 According to *SNT-TC-IA*, which of the following is not true for a Level III?
- Shall be capable of assisting in establishment of acceptance criteria.
 - Must train and examine the Level I and II personnel in his/her organization.
 - Should be familiar with other commonly used NDT methods.
 - Shall be capable of establishing techniques and selection of test methods.
- Q.1-18 According to written instructions, an NDT Level I may be qualified to perform:
- specific calibrations.
 - specific nondestructive tests.
 - specific evaluations.
 - all of the above, and write reports of test results.
 - only a, b, and c.

Q.1-19 May a Level I independently perform, evaluate, and sign for results of nondestructive tests with supervision and guidance from a Level II or III?

- Yes, the intent in *SNT-TC-1A* is that the Level I may perform the above functions provided that they are in accordance with written instruction of a Level III or designee.
- No, the Level I may perform the above functions in accordance with written procedures, but must be under constant supervision and guidance of a Level II or Level III.
- No, the Level I may not sign for test results.
- No, the Level I is not allowed to take any independent action.
- Yes, provided that the Level I receives detailed verbal instructions from the Level II or III and demonstrates his capability to follow the instructions.

Q.1-20 Which of the following statements is true concerning the definitions of Level I, II, and III in *SNT-TC-1A*?

- The qualifications for Level III equal and exceed those of Level II.
- SNT-TC-1A* was intended for use by employers to determine the proficiency of individuals at each Level.
- Except for a provision for a Trainee, Levels I, II, and III may not be further subdivided. Level III's may not perform Level II functions unless they pass Level II examinations.
- Both a and c are true.

Q.1-21 Which of the following is not within the scope of activities of a Level II individual, as recommended in *SNT-TC-1A*?

- Calibrate equipment.
- Prepare written instructions.
- Establish techniques.
- Provide training.

Q.1-22 As recommended in *SNT-TC-1A*, a Level II:

- may conduct on-the-job training and guidance of Level I personnel, with the Level I training and guiding Trainees.
- is responsible for the training and examination of Level I personnel for certification.
- must be capable of and responsible for establishing techniques.
- all of the above are true.
- none of the above are true.

Q.1-23 According to *SNT-TC-1A*, which of the following is true for a Level III?

- A Level III must have successfully completed at least two years of science or engineering study at a college or university.
- It is desirable that a Level III be a registered professional engineer.
- The Level III is responsible for establishing all acceptance criteria.
- The Level III shall be capable of evaluating test results in terms of codes, standards, and specifications.
- All of the above are true.

Analysis of *SNT-TC-1A*, Section 5

Excerpt from Section 5

5. Written Practice

- The employer shall establish a written practice for the control and administration of NDT personnel training, examination, and certification.
- The employer's written practice should describe the responsibility of each level of certification for determining the acceptability of materials or components in accordance with the applicable codes, standards, specifications, and procedures.
- The employer's written practice shall describe the training, experience, and examination requirements for each level of certification.
- The employer's written practice shall be maintained on file.

Implicit in the use of *SNT-TC-1A* is the requirement that the employer shall develop a written practice. *SNT-TC-1A* provides the guidelines; the written practice sets forth the details. When departures from *SNT-TC-1A* guidelines are made, the written practice should record the departure. It is good practice to record all departures, even when they represent situations in excess and/or with greater strength than the recommendations of *SNT-TC-1A*.

Review Questions for *SNT-TC-1A*, Section 5

- Q.1-24 In accordance with *SNT-TC-1A*, who is responsible for establishing a written practice for the control and administration of NDT personnel training, examination, and certification?
- The NDT Level III.
 - The employer.
 - ASNT.
 - An appropriate regulatory authority.

- Q.1-25 The responsibility of each level of certification for determining the acceptability of materials or components:
- need not be described in the employer's written practice since those responsibilities are defined specifically in *SNT-TC-1A*.
 - should be described in the employer's written practice only if they are different from *SNT-TC-1A* recommendations.
 - should be described in the employer's written practice under all circumstances.
 - should be described in the employer's written practice if dictated by customer requirements.

Analysis of *SNT-TC-1A*, Section 6

Excerpt from Section 6

- 6. Education, Training, and Experience Requirements for Initial Qualification**
- 6.1 Candidates for certification in NDT should have sufficient education, training, and experience to ensure qualification in those NDT methods in which they are being

considered for certification. Documentation of prior certification may be used by an employer as evidence of qualification for comparable levels of certification.

- 6.2 Documented training and/or experience gained in positions and activities comparable to those of Levels I, II, and/or III prior to establishment of the employer's written practice may be considered in satisfying the criteria of paragraph 6.3.
- 6.3 To be considered for certification, a candidate should satisfy one of the following criteria for the applicable NDT level:
- NDT Levels I and II
Table 6.3.1A lists the recommended training and experience factors to be considered by the employer in establishing written practices for initial qualification of Level I and Level II individuals.
Table 6.3.1B lists alternate training and experience factors which may be considered by the employer in establishing written practices for initial qualification of Level I and Level II individuals.
 - NDT Level III
 - Have graduated from a minimum four-year college or university curriculum with a degree in engineering or science, plus one year's experience in NDT in an assignment comparable to that of an NDT Level II in the applicable test method(s), or:
 - Have completed with passing grades at least two years of engineering or science study at a university, college, or technical school, plus two years experience in assignments at least comparable to that of NDT Level II in the applicable test method(s), or:
 - Have four years' experience in NDT in an assignment at least comparable to that of an NDT Level II in the applicable testing method(s).

The above Level III requirements may be partially replaced by experience as a certified NDT Level II or by assignments at least comparable to

Table 1, Initial Training and Experience Levels [same as Table 6.3.1A in Recommended Practice No. SNT-TC-1A (1996)]

Examination Method	Level	Technique	Initial Training (Hours)		Experience Level** (Months)
			High School Graduate or Equivalent	Completion With a Passing Grade of at Least 2 Years of Engineering or Science Study in a University, College or Technical School	
AE	I		40	32	3
	II		40	40	9
ET	I		40	24	3
	II		40	40	9
LT	I	BT	2	2	*
	II	BT	4	2	0.5
	I	PCT	24	16	1.5
	II	PCT	16	12	4
	I	HDLT	12	8	1.5
	II	HDLT	8	6	4
	I	MSLT	40	28	4
	II	MSLT	24	16	6
MT	I		12	8	1
	II		8	4	3
NRT	I		28	20	6
	II		40	40	24
PT	I		4	4	1
	II		8	4	2
RT	I		39	29	3
	II		40	35	9
TIR	I		40	36	3
	II		40	35	18
UT	I		40	30	3
	II		40	40	9
VA	I		24	24	6
	II		80	56	24
VT	I		8	4	1
	II		16	8	2

Techniques: BT = Bubble Test
PCT = Pressure Change Test
HDLT = Halogen Diode Leak Test
MSLT = Mass Spectrometer Leak Test

* = 2 hours

** = Work Time Experience Per Level

Notes:

- (1) For Level II certification, the experience shall consist of time at Level I or equivalent. If a person is being qualified directly to Level II with no time at Level I, the required experience shall consist of the sum of the hours required for Level I and Level II.
- (2) Listed training hours may be adjusted as described in the employer's written practice depending on the candidate's actual education level, e.g., grammar school, college graduate in engineering, etc.
- (3) Initial experience may be gained simultaneously in two or more methods if:
 - (a) the candidate spends a minimum of 25% of work time on each method for which certification is sought, and
 - (b) the remainder of the work time claimed as experience is spent in NDT-related activities defined in the employer's written practice.
- (4) Training shall be outlined in the employer's written practice.

Table 2, Alternate Initial Training and Experience Levels [same as Table 6.3.1B in Recommended Practice No. SNT-TC-1A 9 (1996)]

Examination Method	Level	Technique	Initial Training (Hours)		Experience Level** (Months/Hours)
			High School Graduate or Equivalent	Completion With a Passing Grade of at Least 2 Years of Engineering or Science Study in a University, College or Technical School	
AE	I		40	32	3/210
	II		40	40	9/630
EF	I		40	24	3/210
	II		40	40	9/630
LT	I	BT	2	2	*/3
	II	BT	4	2	0.5/35
	I	PCT	24	16	1.5/105
	II	PCT	16	12	4/280
	I	HDLT	12	8	1.5/105
	II	HDLT	8	6	4/280
	I	MSLJ	40	28	4/280
	II	MSLT	24	16	6/420
MT	I		12	8	1/70
	II		8	4	3/210
NRT	I		28	20	6/420
	II		40	40	24/1680
PT	I		4	4	1/70
	II		8	4	2/140
RT	I		39	29	3/210
	II		40	35	9/630
TIR	I		40	36	3/210
	II		40	35	18/1260
UT	I		40	30	3/210
	II		40	40	9/630
VA	I		24	24	6/420
	II		80	56	24/1680
VT	I		8	4	1/70
	II		16	8	2/140

Techniques:
 BT = Bubble Test
 PCT = Pressure Change Test
 HDLT = Halogen Diode Leak Test
 MSLT = Mass Spectrometer Leak Test

* = one (1) day

** = Work time experience per level shall be required over the time frame in 1/2 to 3 times the months shown and shall include a minimum of the hours shown in the specific method for which certification is sought.

NDT Level II in other methods listed in Section 3 of this Recommended Practice as defined in the employer's written practice.

See Table 1, *Recommended Initial Training and Experience Levels* and Table 2, *Alternate Initial Training and Experience Levels*.

Inquiries for SNT-TC-1A, Section 6

Section 6 has elicited a relatively large number of inquiries to the *SNT-TC-1A* Interpretation Panel. **NOTE:** Inquiries are numbered to include the year of the inquiry and always refer to the edition of *SNT-TC-1A* in effect in that year, unless otherwise stated in the question. SNT-TC-1A was published in these years: 1968, 1975, 1980, 1984, 1988, 1992, 1996, 2001.

1. Inquiry 77-4

Inquiry:

May the experience requirements expressed as "certified NDT Level II" in paragraph 6.3.1(b), (c), and (d) of the 1975 Edition of *SNT-TC-1A* be considered to include experience gained in "an assignment comparable to that of an NDT Level II" [as stated in paragraph 6.3.2(a)] in determining the prerequisite requirements of a candidate for certification as a Level III? If so, may this acceptance of experience in "an assignment comparable to" be extended to include similar subparagraphs under paragraph 6.2.5 of the earlier editions of *SNT-TC-1A*?

Response:

Paragraph 6.2 of the 1975 Edition of *SNT-TC-1A* states, "Documented training and/or experience gained in positions and activities equivalent to those of Level II, or Level III prior to establishment of the employer's written practice and a certification program in accordance with his document shall be considered as satisfying the criteria of Paragraph 6.2.1 and 6.3." If documentation was not produced during such prior experience, an affidavit or other suitable testimony regarding such experience may be evaluated by the employer to aid in determining equivalence. This response applies to the 1975 Edition and all prior editions of *SNT-TC-1A*.

2. Inquiry 76-1

Inquiry:

Table 6.2.1A contains the statement, "Credit for experience may be gained simultaneously in two or more disciplines. The candidate must spend at least 25 percent of his work time on each discipline for which experience is being claimed." Our question is this: Over what time period does the term "simultaneously" apply?

Response:

The employer's written practice should specify the time period over which simultaneous experience shall be credited.

3. Inquiry 78-3

Inquiry:

With reference to the note in Table 6.2.1A, "Credit for experience may be gained simultaneously in two or more disciplines. The candidate must spend at least 25 percent of his work time on each discipline for which certification is being claimed," is it intended that an individual being qualified in only one method could obtain the work time experience in 25 percent of the times tabulated in Table 6.2.1A?

Response:

No, an individual being qualified in only one Method should spend at least 25 percent of his work time in that method and should obtain the total work time experience as recommended in consecutive months as though the remainder of his work time was spent in qualifying for other NDT methods simultaneously

4. Inquiry 76-2

Inquiry:

1. For requalification of Level I and II NDT personnel, does paragraph 6.2.1 imply that you must keep continuous records by the hour showing that the individual has continuously spent at least 25 percent of his work time working in each method to which qualified?
2. Because of the 25 percent used in the note to Table 6.2.1A, it has been implied that an individual at maximum could be qualified in only four methods, and this would be true only if he could show that

exactly 25 percent of his work time was spent in each of four methods. Was this the intent of *SNT-TC-1A*?

Response:

1. No. Table 6.2.1A applies only to initial experience required for qualification; it is not applicable to requalification.
2. No. The candidate may be qualified in as many methods as desired. The 25 percent work time experience only applies to the work time experience required for initial qualification in each level for each method. The 25 percent is not applicable and is not required for the individual to remain qualified in a particular method at a specific qualification level.

5. Inquiry 80-3

Inquiry:

A candidate spends 50 percent of his time performing radiography, 25 percent performing magnetic particle examinations, and the remaining 25 percent performing liquid penetrant examinations. At the end of a one month period, assuming a 144 hour month, is Method A or Method B a correct computation of working time experience for certification to a Level I rating?

Method A: The candidate claims work time experience of 144 hours for each of the three methods.

Method B: The candidate claims work time experience of 72, 36, and 36 hours for radiography, magnetic particle, and liquid penetrant, respectively.

Response:

The method described in Method A is that intended by the *SNT-TC-1A*. In other words, the examiner may claim full-time for all the NDT methods in which he works simultaneously. It is not intended that he claim time for work hours spent in work other than nondestructive testing.

6. Inquiry 80-6

Inquiry:

Table 6.2.1A for *SNT-TC-1A* provides: "credit for experience may be gained simultaneously in two or more disciplines. The candidate must spend at least 25 percent of his

work time on each discipline for which experience is being claimed." Does this statement mean (as it regards Level I PT) that if the candidate is already a qualified Level I or Level II radiographer, the one month work experience can be reduced to 44 hours?

Response:

It is the intent of this statement that a candidate may take credit for work performed in two methods simultaneously because of the knowledge interchange factor believed to be present in such activities. It is not intended that an examiner certified in one method could at some time later reduce the requirements for certification in another method except as defined in the employer's written practice.

7. Inquiry 79-1

Inquiry:

In maintaining records, if an individual is working simultaneously in more than one method, should the records reflect the total time spent for each method or should the time be divided proportionately for each of the methods? For example, if an individual spent 50 percent of his time on ultrasonic testing and 50 percent of his time on radiographic testing for a period of 9 months, would the record show experience in UT of 4.5 months or 9 months?

Response:

It is intended that the employer's written practice should include details of maintaining records. It is intended that records should reflect the facts of each individual's work time with regard to the amount of time spent on each Method and the periods of time during which the work was performed.

8. Inquiries 79-14 and 79-15

Inquiry:

Is it intended per *SNT-TC-1A* (1975 Edition) that the time spent in a laboratory exercise during a long term NDT course be considered the only qualifying work time experience?

May the laboratory time be given any credit at all as "work time experience" to satisfy the requirements in Table 6.2.1A?

Response:

It is not intended that laboratory experience in an educational program be directly applied to the work time experience. Laboratory experience is not necessarily applicable to the employer's product or to the specific codes, standards, or specifications in use. However, in recognition of the benefits accruing from laboratory experience, the employer may include such consideration for adjustment to the work experience in his written practice. Should the employer decide to do so, he should thoroughly evaluate the curriculum to determine its applicability.

**General Comments about *SNT-TC-1A*,
Section 6**

Paragraph 6.3.1, like the rest of *SNT-TC-1A*, is only a guide. The employer's written practice should detail all such requirements, which may differ from the recommendations of paragraph 6.3.1.

Inquiry 1 points to consideration given in *SNT-TC-1A* to the initial establishment of a formal qualification and certification program. Paragraph 6.2 recognizes that prior to establishing a program and a written practice, the employer may have provided training as well as other essentials of qualifying NDT personnel without formal procedures. Hence, documentation of such activities could provide evidence of the equivalence of prior activities with those recommended in *SNT-TC-1A*. Paragraph 6.3.1.1, 6.3.1.2, and 6.3.1.3 use the phrase "... in an assignment at least comparable to that of an NDT Level II ..." In other words, the experience can be "comparable to that of an NDT Level II" if documentation can be produced that evidences the comparability.

Inquiries 2 through 8 all question in one way or another the intent underlying the note in Table 6.3.1, "Initial experience may be gained simultaneously in two or more methods if the candidate spends a minimum of 25 percent of his work time on each method for which certification is sought."

Where an individual is doing NDT and only NDT full-time, the note and the responses to the inquiries are clear. The rationale behind the apparent reduction in total hours spent doing one method of NDT when other NDT is being done is that a synergistic effect is recognized. Full-time involvement in several methods of NDT can produce more effective experience in

each method by virtue of the interrelationships among the methods and the effect of full-time attention to NDT. Consider the case of an individual who is assigned full time to one method of NDT. Frequently, what is learned by experience in the first few days or weeks is all that is learned. Further on-going experience may just be repetition of what was learned during an initial period. On the other hand, an individual alternating his/her work experience between two or three (or more) methods may obtain more varied and more interrelated experience with the experience in each method reinforcing the experience in the others. This individual is also receiving more "real hours" of training, if he/she is preparing to qualify in more than one method. Similar synergistic effects are possible.

Unfortunately, the situation that is not precisely covered involves personnel who are utilized in performing NDT part-time and some other nonrelated function for the remaining time. For example, suppose a small manufacturer has been manufacturing items that have not required NDT. Deciding to expand its product line, the manufacturer makes a product that requires one method of NDT and decides to procure the necessary equipment to perform NDT with existing inspection personnel. For the sake of continuing this scenario, suppose that the manufacturer decides to train and qualify a dimensional inspector to do the NDT. Further, suppose that the NDT will only occupy 25 to 30 percent of the inspector's time with the remainder spent doing dimensional inspection.

It cannot be definitely concluded that the individual in this example is not benefiting from this divided experience to the extent of an individual working full-time in NDT. However, some feel that there is such a rationale and that such differences in the content of experience should be considered. If so, the experience time recommended for such cases should be extended to approach or equal the total experience time recommended. If the recommended experience time for the particular method of the example is one month, then the employer's written practice might prudently require that, regardless of elapsed time, the individual would be qualified only after having spent 175 hours (one work month) in actual performance of NDT.

For initial qualification in one, two, three, or even four methods simultaneously, and if the individual is working full-time in performance of NDT, the employer should state in its written practice their specific approach to the consideration of interrelated and simultaneous experience.

Review Questions for *SNT-TC-1A*, Section 6

Q.1-26 What factors are to be considered to ensure that a candidate for certification in NDT understands the principles and procedures involved?

- Training, experience, and education
- Training, experience, and prior certifications held
- Education, experience, and percentage of time on the job doing NDT
- Training, experience, and professional credentials
- Training, experience, and familiarity with the employer's product and customer requirements

Q.1-27 As recommended in *SNT-TC-1A*, which of the following is true?

- Overtime cannot be considered in meeting the minimum experience.
- Overtime can only be considered if the candidate is being qualified in more than one method simultaneously.
- Overtime can be credited based on total hours.
- SNT-TC-1A* does not currently provide a recommendation regarding overtime.

Q.1-28 High school education is recommended as a minimum requirement for:

- Level III only.
- Level II and Level III only.
- none of the levels.
- all three levels.

Q.1-29 In leak testing, recommended work time experience and training:

- differs for each of four major techniques.
- does not consider different techniques.
- is listed for Levels II and III only.
- is significantly greater than for ultrasonic testing.

Q.1-30 It is recommended that the education and experience of a Level III candidate include:

- graduation from a 4-year university or college with a degree in engineering or science college or university plus 1 years' experience in NDT comparable to that of a Level II.
- graduation from a 4-year college or university with a degree in NDT plus 3 months' experience in NDT comparable to that of a Level II.
- 2 years' experience in NDT comparable to that of a Level II if a high school graduate.
- 6 years' experience in NDT if the candidate did not graduate from high school.
- both a and b.

Q.1-31 Records substantiating qualification are recommended to be kept on a:

- daily or weekly basis.
- monthly or hourly basis.
- fractional yearly basis.
- fractional hourly basis.
- none of the above.

Q.1-32 For a person being qualified directly to Level II with no time at Level I, the recommended experience consists of:

- the time recommended for Level II.
- the time recommended for Level III.
- the sum of the times recommended for Level I and Level II.
- not less than 6 months for any method.
- the sum of the times recommended for a Trainee and Level I.

- Q.1-33 In some cases, the training times recommended for Level I are greater than for Level II. Why?
- In preparing for qualification at Level I, the candidate should always receive more training than for Level II, regardless of the NDT method.
 - Some numbers in the table are erroneous.
 - Candidates for Level II generally have more formal education than those for Level I.
 - Some methods require more initial training at Level I because of differences in complexity and manipulative skills.

- Q.1-34 The recommended number of training hours in a particular method are:
- listed as a function of the candidate's education.
 - the same regardless of the candidate's education.
 - listed as a function of the candidate's experience.
 - reduced if the candidate is being qualified in more than one method simultaneously.
 - increased if the candidate is not working full-time in NDT.

Analysis of SNT-TC-1A, Section 7

Excerpt from Section 7

7. Training Programs

- 7.1 Personnel being considered for initial certification should complete sufficient organized training to become thoroughly familiar with the principles and practices of the specified NDT method related to the level of certification desired and applicable to the processes to be used and the products to be tested.
- 7.2 The training program should include sufficient examinations to assure that the necessary information has been comprehended.
- 7.3 Recommended training course outlines for Levels I, II, and III personnel and recommended references which may be used as technical source material follow in

the Recommended Training Courses section of this Recommended Practice.

- 7.4 The employer who purchases outside training services is responsible for assuring that such services are in accordance with the employer's written practice.

Review Questions for SNT-TC-1A, Section 7

- Q.1-35 It is recommended that a training program for qualification and certification purposes should include:
- organized training in the principles and practices of the method.
 - training applicable to the practices to be used and the products to be tested.
 - examination to verify that the training material has been comprehended.
 - all of the above.
 - only a and c.
- Q.1-36 Recommended training course outlines:
- are included in SNT-TC-1A and must not be modified.
 - are not included in SNT-TC-1A.
 - are not available for visual and leak testing.
 - are included in SNT-TC-1A for the methods listed.

- Q.1-37 For candidates with different educational backgrounds, recommended instruction periods are:

- the same regardless of educational background.
- the same regardless of educational background, but different for Level I and Level II.
- different based on educational background.
- different based on educational background, but the same for Level I and Level II.

Q.1-38 Recommended training reference material:

- a. is available only through ASNT.
- b. is available from a variety of sources.
- c. can only include those references listed.
- d. must be made available to each trainee.
- e. is completely contained in the *Nondestructive Testing Handbook*.

Q.1-39 The recommended training course subject outline includes:

- a. technical principles of the method.
- b. procedures and equipment usage.
- c. technical principles and interpretation of indications.
- d. technical principles and equipment usage.
- e. a combination of all of the above.

Analysis of SNT-TC-IA, Section 8

Excerpt from Section 8

8. Examinations

8.1 Administration and Grading

1. An NDT Level III individual shall be responsible for the administration and grading of examinations specified in Section 8.3 through 8.8 for NDT Level I, II, or other Level III personnel. The administration and grading of examinations may be delegated to a qualified representative of the NDT Level III and so recorded. The actual administration and grading of Level III examinations specified in 8.8 may be performed by a qualified representative of the employer.
2. For Level I and II personnel, a composite grade should be determined by simple averaging of the results of the general, specific, and practical examinations described below. For Level III personnel, the composite grade should be determined by simple averaging of the results of the basic, method, and specific examinations described below.
3. Examinations administered for qualification should result in a passing

composite grade of at least 80 percent, with no individual examination having a passing grade less than 70 percent.

4. When an examination is administered and graded for the employer by an outside agency and the outside agency issues grades of pass or fail only, on a certified report, then the employer may accept the pass grade as 80 percent for that particular examination.
5. The employer who purchases outside services is responsible for assuring that the examination services are in accordance with the employer's written practice.

8.2 Vision Examinations

1. **Near-Vision Acuity.** The examination should assure natural or corrected near-distance acuity in at least one eye such that the applicant is capable of reading a minimum of Jaeger Number 2 or equivalent type and size letters at a distance of not less than 12 in. (30.5 cm) on a standard Jaeger test chart. The ability to perceive an Ortho-Rater minimum of 8 or similar test pattern is also acceptable. This should be administered annually.
2. **Color Contrast Differentiation.** The examination should demonstrate the capability of distinguishing and differentiating contrast among colors or shades of gray used in the method as determined by the employer. This should be conducted upon initial certification and at three-year intervals thereafter.

8.3 General (Written - For NDT Levels I and II)

1. The general examinations should address the basic principles of the applicable method.
2. In preparing the examination, the NDT Level III should select or devise appropriate questions covering the applicable method to the degree required by the employer's written practice.
3. The minimum number of questions which should be given is shown in Table 3.

8.4 Specific (Written - For NDT Levels I and II)

1. The specific examination should address the equipment, operating procedures, and NDT techniques that

Table 3, Questions for Level I/II

Method	General Examination		Specific Examination	
	Level I	Level II	Level I	Level II
Acoustic Emission	40	40	20	20
Electromagnetic Testing	40	40	20	20
Leak Testing	20	20		
Bubble			15	15
Pressure Change			15	15
Halogen Diode			15	15
Mass Spectrometer			20	40
Liquid Penetrant	30	30	20	15
Magnetic Particle	30	30	20	15
Neutron Radiographic	40	40	15	15
Radiographic	40	40	20	20
Infrared/Thermal	40	40	20	20
Ultrasonic	40	40	20	20
Vibration and Analysis	40	40	20	60
Visual	30	30	20	20

the individual may encounter during specific assignments to the degree required by the employer's written practice.

2. The specific examination should also cover the specifications or codes and acceptance criteria used in the employer's NDT procedures.
3. The minimum number of questions which should be given is shown in Table 3.

8.5 Practical (for NDT Level I and II)

1. The candidate should demonstrate familiarity with and the ability to operate the necessary test equipment, record, and analyze the resultant information to the degree required.
2. At least one selected specimen should be tested and the results of the NDT analyzed by the candidate.
3. The description of the specimen, the test procedure, including checkpoints, and the results of the examination should be documented.
4. NDT Level I Practical Examination. Proficiency should be demonstrated in performing the applicable NDT on one or more samples approved by the NDT Level III and in evaluating the results to the degree of responsibility as

described in the employer's written practice. At least ten (10) different checkpoints requiring an understanding of test variables and the employer's procedural requirements should be included in this practical examination.

5. NDT Level II Practical Examination. Proficiency should be demonstrated in selecting and performing the applicable NDT technique within the method and interpreting and evaluating the results on one or more samples approved by the NDT Level III. At least ten (10) different checkpoints requiring an understanding of NDT variables and the employer's procedural requirements should be included in this practical examination.

8.6 Sample questions for general examinations are presented in separate Supplements to SNT-TC-1A (Q&A Books) which can be obtained from ASNT Headquarters. These questions are intended as examples only and should not be used verbatim for qualification examinations.

8.7 All Level I, II, and III written examinations should be closed book except that necessary data, such as graphs, tables, specifications, procedures, and codes, may

be provided with or in the examination. Questions utilizing such reference materials should require an understanding of the information rather than merely locating the appropriate answer. All questions used for Level I and Level II examinations should be approved by the responsible Level III.

8.8 NDT Level III Examinations

1. Basic Examination (required only once when more than one method of examination is taken). The minimum number of questions is as follows:
 - a. Fifteen (15) questions relating to understanding the *SNT-TC-1A* document.
 - b. Twenty (20) questions relating to applicable materials, fabrication, and product technology.
 - c. Twenty (20) questions that are similar to published Level II questions for other appropriate NDT methods.
2. Method Examination (for each method).
 - a. Thirty (30) questions relating to fundamentals and principles that are similar to published ASNT NDT Level III questions for each method, and
 - b. Fifteen (15) questions relating to application and establishment of techniques and procedures that are similar to the published ASNT NDT Level III questions for each method, and
 - c. Twenty (20) questions relating to capability for interpreting codes, standards, and specifications relating to the method.
3. Specific Examination (for each method).
 - a. Twenty (20) questions relating to specifications, equipment, techniques, and procedures applicable to the employer's product(s) and methods employed, and to the administration of the employer's written practice.

- b. The employer may delete the specific examination if the candidate has a valid ASNT NDT Level III certificate in the method and if documented evidence of experience exists, including the preparation of NDT procedures to codes, standards, or specifications and the evaluation of test results.

4. A valid endorsement on an ASNT NDT Level III certificate fulfills the examination criteria described in 8.8.1 and 8.8.2 for each applicable NDT method.

8.9 Reexamination

Those failing to attain the required grades must wait at least thirty (30) days or receive suitable additional training as determined by the NDT Level III before reexamination.

Inquiries for *SNT-TC-1A*, Section 8

NOTE: Inquiries are numbered to include the year of the inquiry and always refer to the edition of *SNT-TC-1A* in effect in that year, unless otherwise stated in the question. *SNT-TC-1A* was published in these years: 1968, 1975, 1980, 1984, 1988, 1992, 1996, 2001.

1. Inquiry 78-1

Inquiry:

If a Level II examination is administered to a Level I individual, is there a need, when that individual is eligible for Level II Certification, to readminister the same Level II examination provided that all other criteria, for example, education, training, and experience, have been satisfied?

Response:

It is not intended that the individual should be reexamined, provided that the original Level II examination was passed and all applicable requirements of the employer's written practice have been met per paragraph 8.1 of *SNT-TC-1A*.

2. Inquiry 79-13

Inquiry:

If an employee performs NDT to multiple codes, specifications, and acceptance standards, is it necessary to include questions relating to

each code, specification, or acceptance standard in this specific examination?

Paragraph 9.6.1(c) requires records of educational background to be included in personnel records. Is information supplied by the employee (i.e., such as a résumé or employment application) satisfactory evidence of educational accomplishments or is conclusive evidence (i.e., such as a copy of a diploma or transcript) required for verification?

Response:

It is the intent of paragraph 8.2(c2) that the specific examination cover all codes, specifications, and acceptance standards applicable to the employee's activities.

3. Inquiry 79-2

Inquiry:

Since NDT Level III general examination questions in some methods are available from ASNT (Questions and Answers for Qualifying NDT Level III Personnel, October 1977), is it intended that the Level III questions referred to in paragraphs 8.4 and 8.5.3(a) be selected from those published by ASNT?

Response:

It is intended that the recommended 30 questions devised by the examiner for the appropriate method [paragraph 8.5.3(a)] be devised or selected as appropriate to the degree required by the employer's written practice. As with all questions and answers provided by ASNT, those mentioned are suggested as guidelines and supplied as an aid to employers in preparing examinations. It is intended that the provisions of paragraph 8.4 be superseded when questions of a character unique to Level III qualifications as delineated in paragraph 4.3(c) are devised or selected by the employer for use in the Level III General Examination. The additional 30 questions from Level II questions for other applicable NDT methods as recommended in paragraph 8.5.3(a) are intended to be selected from methods other than that for which the candidate is being examined. It is intended that the employer use such questions to determine that the candidate has sufficient knowledge of other NDT methods that might be applicable to the employer's particular circumstances. For example, it could be appropriate that a

candidate being examined for Level III qualification in a particular method be required to demonstrate basic knowledge in one or more other methods in order to "designate the particular test method and technique to be used." See paragraph 4.3(c).

4. Inquiry 80-2

Inquiry:

In reference to the practical examination, there are several approaches that may be taken. For example, grades on checkpoints could be given as 1 (correct) or 0 (incorrect) or could be given in a graduated fashion, say from 0 to 5, depending on the correctness and efficiency of the application. Which approach is correct? Could a questionnaire for which written answers would be prepared as an alternative method of grading be used?

Response:

Please refer to paragraphs 8.5.1(c) and 9.6.1(f). Either of the proposed grading methods is permissible depending on the needs of the employer. Other approaches may also be taken. The approach which meets the needs of the employer should be described in his written practice and followed for the practical examination. The last technique proposing a questionnaire for which written answers would be prepared would fall more appropriately under the specific examination category.

Review Questions for SNT-TC-1A, Section 8

Q.1-40 In accordance with SNT-TC-1A, the NDT Level III shall be responsible for:

- a. grading individual certification examinations.
- b. training and examination of NDT Level I and Level II personnel.
- c. all questions to be used on examinations for Level I and Level II.
- d. all of the above.

- Q.1-41 Which of the following may conduct and grade examinations for Level I and Level II personnel?
- An NDT Level III.
 - A selected representative of the NDT Level III.
 - ASNT personnel because they offer examinations on a regular basis.
 - All of the above.
 - Both a and b.
- Q.1-42 Of the following personnel, who can administer the near-distance, visual acuity examination using the reading card with Jaeger letters?
- An NDT Level III.
 - A selected representative of the NDT Level III.
 - A plant nurse, if so designated by the NDT I Level III.
 - All of the above.
- Q.1-43 As recommended in *SNT-TC-1A*, physical examination requirements are intended to be:
- the same for all methods.
 - the same for all employers.
 - related to each employer's specific needs.
 - as specified in applicable sections of the *ASME Boiler and Pressure Vessel Code*.
 - as stated in all of the above.
- Q.1-44 The general examination is intended to cover:
- basic test principles unique to the employer's needs.
 - Only the material included in the training course outlines of *SNT-TC-1A*.
 - the equipment operational capabilities of the candidate.
 - the operating procedures that the candidate may encounter in his job.
 - all of the above.
- Q.1-45 Questions and answers available from ASNT are intended for use in compiling:
- the General Examination only.
 - the Specific, Practical, and General examinations.
 - the Basic and Method examinations.
 - the General and Basic examinations.
 - the General, Basic, and Method examinations.
- Q.1-46 Which of the following parts of Level I and Level II examinations should be written?
- The General and Specific.
 - The General and Practical.
 - The General, Specific, and Practical.
 - Only the General.
- Q.1-47 The practical examination is recommended to include operational familiarity with test equipment and analysis of test results for:
- Levels I, II, and III.
 - Levels I and II.
 - Levels II and III.
 - Trainees, Level I, and Level II.
 - Trainees, Levels I, II, and III.
- Q.1-48 Which of the following statements is true with regard to the administration of written examinations?
- The examinee should not be permitted access to any reference material.
 - Reference data may be supplied for the practical examination only.
 - Level III personnel should be required to memorize everything except codes, specifications, and procedures.
 - Codes, specifications, and procedures may be provided to examinees for reference during examinations provided that they do not contain data that can be used to answer questions in the general examination.

Q.1-49 For the written examinations, tables, graphs, and charts:

- a. may be used during Level I examinations.
- b. may be used during Level II examinations.
- c. may be used during Level III examinations.
- d. may be used during all of the above.
- e. may not be used.

Q.1-50 For Level I and Level II Practical Examinations, one or more test specimens are recommended and the examinee should perform tests and evaluations using the appropriate equipment and test specimens. The minimum number of different checkpoints recommended is:

- a. 5.
- b. 10.
- c. 15.
- d. 20.
- e. none of the above.

Q.1-51 In certification of Level III personnel according to the recommendations of *SNT-TC-1A*, the employer:

- a. must give written examinations.
- b. must give General and Specific examinations.
- c. may delete the Specific Examination.
- d. can waive written examinations if oral examinations are given in their place.

Q.1-52 For Level I and II examinations, the recommended minimum composite score is:

- a. 60 percent.
- b. 90 percent.
- c. 70 percent.
- d. 80 percent.

Q.1-53 For Level III Basic Examinations, it is recommended that Level II questions also be included. These questions should be:

- a. in addition to those for the particular Method Examination, and should be based on other applicable NDT methods.
- b. based on Level II tasks for the particular Method Examination.
- c. selected at random from questions previously used on Level II examinations.
- d. given only if the candidate is being examined in more than one method.

Analysis of *SNT-TC-1A*, Section 9

Excerpt from Section 9

9. Certification

- 9.1 Certification of all levels of NDT personnel is the responsibility of the employer.
- 9.2 Certification of NDT personnel shall be based on demonstration of satisfactory qualification in accordance with Sections 6, 7, and 8, as modified by the employer's written practice.
- 9.3 At the option of the employer, an outside agency may be engaged to provide NDT Level III services. In such instances, the responsibility of certification is retained by the employer.
- 9.4 Personnel certification records shall be maintained on file by the employer and should include the following:
 1. Name of certified individual.
 2. Level of certification and NDT method.
 3. Educational background and experience of certified individuals.
 4. Statement indicating satisfactory completion of training in accordance with the employer's written practice.
 5. Results of the vision examinations prescribed in paragraph 8.2 for the current certification period.
 6. Current examination copy(ies) or evidence of successful completion of the examinations.
 7. Other suitable evidence of satisfactory qualifications when such qualifications are used in lieu of the specific examinations prescribed in 8.8.3(b) or

- as prescribed in the employer's written practice.
8. Composite grade(s) or suitable evidence of grades.
 9. Dates of certification and/or recertification and the dates of assignment to NDT.
 10. Signature of employer's certifying authority.
- 9.5 Recertification
1. All levels of NDT personnel should be recertified periodically in accordance with one of the following criteria:
 - a. Evidence of continuing satisfactory performance.
 - b. Reexamination in those portions of the examinations in Section 8 deemed necessary by the employer's NDT Level III.
 2. Recommended maximum recertification intervals are:
 - a. Levels I and II - 3 years
 - b. Level III - 5 years
 3. NDT personnel may be reexamined any time at the discretion of the employer and have their certifications extended or revoked.
 4. The employer's written practice should include rules covering the duration of interrupted service that requires reexamination and recertification.
3. Paragraph 9.1 states that the certification of all levels is the responsibility of the employer. Paragraph 9.5 recognizes the use of outside certification services. May an employer subcontract nondestructive testing to an outside organization utilizing that organization's certifications for Level I, II, and III provided that the results of the employer's audit of that organization are satisfactory? Must the employer certify NDT personnel, or may he accept the outside organization's certification?

Response:

1. It is intended that Level III services may be obtained from an outside agency for the purpose of training and examining NDT personnel. It is beyond the scope of *SNT-TC-IA* to recommend whether or not outside inspection services should be obtained. It is definitely not intended that the employer be restricted from utilizing any outside NDT services.
2. The intent of paragraph 9.5 is to emphasize the responsibility of the employer to assure by audit that any and all parts of purchased services attendant to qualification of NDT personnel are within the same guidelines that the employer himself would follow in accordance with his written practice.
3. The intent underlying paragraph 9.1 is fundamental. When outside Level III services are used for the purpose of qualifying and certifying personnel, it is intended that the employer utilizing such services be responsible for assuring that those services are properly performed and audited. Whether or not the employer uses outside Level III services for the training and examining of his NDT personnel, the total responsibility for certification of all levels rests with the employer of the individuals.

SNT-TC-IA only provides guidelines for qualification and certification of NDT personnel. Outside services referred to in section 9 are those intended to be used by an employer only for the purposes of training, examining, or otherwise qualifying individuals directly employed by the employer.

When the performance of NDT is subcontracted to an outside organization and

Inquiries for *SNT-TC-IA*, Section 9

NOTE: Inquiries are numbered to include the year of the inquiry and always refer to the edition of *SNT-TC-IA* in effect in that year, unless otherwise stated in the question. *SNT-TC-IA* was published in these years: 1968, 1975, 1980, 1984, 1988, 1992, 1996, 2001.

1. Inquiry 77-3

Inquiry:

With respect to paragraphs 9.4 and 9.5 of *SNT-TC-IA*,

1. Is it the intent to restrict an employer to engage only Level III services from an outside agency, or may Level I and Level II services also be utilized?
2. Is it intended in paragraph 9.5 that an employer may subcontract training, examination, and certification for all levels, provided the employer's audit results are found to be satisfactory?

the outside organization is the direct employer of the individual performing NDT, the outside organization is the "employer" in terms of *SNT-TC-1A*. Whether the outside organization is properly qualifying and certifying its NDT personnel can only be determined by the purchaser of such outside services, and how such determination is made is a contractual matter between the purchaser and the outside organization.

2. Inquiry 77-10

Inquiry:

What is the intent regarding employers' attempts to verify an individual's experience and performance with past employers in order to maintain the documentation recommended in paragraph 9.6.1?

Response:

The specific documentation to be furnished by new employees and past employers and the means for obtaining documentation is referenced in paragraphs 9.6 and 10.2 of *SNT-TC-1A*. Details should be included in the employer's written practice.

NOTE: As published above and in *Materials Evaluation*, October 1977, in response to Inquiry 77-4, "If documentation was not produced during ... prior experience, an affidavit or other suitable testimony regarding such experience may be evaluated by the employer ..." While Inquiry 77-4 was related to a somewhat different matter, the intent behind the response applies equally to this inquiry (77-10).

3. Inquiry 77-12

Inquiry:

1. Is it intended that an employer may use more than one outside agency for providing Level III services?
2. Is it intended that an employer may use Level III individuals in its direct employment and also use an outside agency for Level III services?
3. Is it intended that certification examinations may be administered without direct supervision and monitoring?

Response:

1. There is no intent to restrict the number of outside agencies from which an employer could use Level III services.
2. Yes, both the above and this situation may be used under circumstances as described in the employer's written practice.
3. It is not intended that unsupervised examinations be administered.

4. Inquiry 89-4

Inquiry:

In the 1968, 1975, 1980 and 1984 Editions of *SNT-TC-1A*, an employer may waive examinations for the Level III and thereby "certify" the individual by appointment.

There is no such provision in the 1988 Edition. However, it is implied by the statement in Paragraph 6.3.2: "When the individual (Level III) is qualified by examination ..."

May the employer waive examination for the Level III and be in compliance with the intent of *SNT-TC-1A* (1988 Edition)?

Response:

It is intended by the 1988 Edition of *SNT-TC-1A* that all Level IIIs initially certified after issuance of the 1988 Edition of *SNT-TC-1A* be qualified by examination.

Also see Inquiry 90-2 and Inquiry 92-2.

5. Inquiry 90-2

Inquiry:

1. Is it the intent of ASNT that all Level III personnel certified to the 1988 Edition be examined?
2. In accordance with *SNT-TC-1A* (1988 Edition), an employer certifies his corporate Level III by examination through an outside service. However, the outside service's Level III was certified by appointment to *SNT-TC-1A* (1984 Edition). Is the employer's Level III certification valid to the 1988 *SNT-TC-1A*?

Response:

1. Yes. As stated in the response to Inquiry 89-4, "... It is intended by the 1988 Edition of *SNT-TC-1A* that all Level IIIs initially certified after issuance of the 1988 Edition of *SNT-TC-1A* be qualified by

examination." See Inquiry 89-4 and Inquiry 92-2.

2. Yes, provided the employer has assured that the examination services are in accordance with the employer's written practice per Paragraph 9.5 of *SNT-TC-1A* (1988 Edition).

6. Inquiry 90-4

Inquiry:

Is it acceptable for a candidate for Level III certification under *SNT-TC-1A* (1988 Edition) to be qualified on the basis of demonstrated ability, achievement, experience and education in lieu of qualification by examination as stated in Paragraph 9.6(g)?

Response:

No. Paragraph 8.8 specifically requires that a Level III candidate be qualified by examination. Paragraph 9.6(g) addresses the content of the qualification records file to be maintained by the employer of certified personnel.

Note: This response was reconsidered. See Inquiry 92-2. Also see Inquiry 89-4 and Inquiry 90-2.

7. Inquiry 96-3

Inquiry:

When applying *SNT-TC-1A* 1992 Edition in strict accordance with the document, is it ASNT's interpretation that Level III must be examined?

Response: (Reconsideration of Inquiry 90-4)

No. Certification of all levels of NDT personnel is the responsibility of the employer. It is the intent of ASNT to certify Level IIIs by examination. However, the employer can specify the requirements for a certification route without examination in the employer's written practice. Please see Inquiry 80-9, Inquiry 89-4, Inquiry 90-2, Inquiry 90-4 and Inquiry 92-2.

General Comments about *SNT-TC-1A*, Section 9

Two of these inquiries relate to situations where employers, for various reasons, must resort to sources outside the employer's organization to provide services attendant to training, examination, and other activities that

require qualified NDT personnel to conduct. Some companies cannot afford, or may not have time to develop, training sources and examinations to qualify their NDT personnel. Others simply prefer to contract such services as needed. For whatever reasons outside services may be needed or desired, the responses above merely reinforces the basic principles underlying *SNT-TC-1A*.

"Certification of all levels of NDT personnel is the complete responsibility of the employer" and "the employer shall establish written practices covering all phases of certification including training as specified in section 5."

Inquiries 89-4, 90-2, 90-4, and 96-3 address the issue of whether a Level III must take an examination in order to become certified. This is of special note, in that versions prior to the 1988 Edition clearly permitted examination waivers for the NDT Level III, leading to the concept of certification by "appointment." This latter practice has been strongly criticized throughout industry since it is perceived as a loop-hole for employers to certify underqualified individuals to assume the key role of administering the NDT activities within an organization. In order to restrict this practice, the 1988 Edition of the recommended practice called for Level IIIs to be qualified by examination. But being a recommended practice that encourages employers to adapt their respective requirements based on each set of circumstances, the opportunity still remains open to employers to "appoint" their Level IIIs, as long as their written practice reflects this strategy as one of their permitted options.

Review Questions for *SNT-TC-1A*, Section 9

Q.1-54 If an outside agency is engaged to provide Level III services, the:

- a. written practice of the outside agency pertains, and it is not necessary for the employer that uses the outside services to have a written practice.
- b. responsibility of certification must be retained by the employer utilizing outside services.
- c. employer utilizing outside services must nonetheless have a Level III in direct employment.

- d. outside agency may certify the personnel of the employer utilizing outside services.

Q.1-55 Which of the following statements is true concerning recertification?

- Recertification can be accomplished only by reexamination at least once every three years.
- Recertification can be based upon evidence of continuing satisfactory performance.
- Once certified to a particular level, certification can only be terminated if the certified individual terminates employment with the certifying employer.
- Reexamination of a certified individual can be accomplished only after three years at a particular level.

Q.1-56 What purpose is best served by maintaining certification records and the written practice?

- For periodic approval by ASNT.
- To determine the effectiveness of outside services.
- To provide documentation for review by customer, clients, and regulatory agencies.
- To protect against product liability claims.
- To satisfy requirements of the *ASME Boiler and Pressure Vessel Code*.

Q.1-57 The employer is responsible for certification of:

- Level I and Level II NDT personnel.
- Level III personnel only.
- outside services.
- all levels of NDT personnel.
- both b and c.

Q.1-58 The employer can consider an individual to be qualified to Level III, but only if he/she:

- takes a comprehensive written examination.
- has in excess of five years experience comparable to a Level II.
- meets the requirements of the employer's written practice.
- has taken the ASNT NDT Level III Basic and at least one of the Method examinations.

Analysis of SNT-TC-1A, Section 10

Excerpt from Section 10

10. Termination

10.1 The employer's certification shall be deemed revoked when employment is terminated.

10.2 A Level I, Level II, or NDT Level III whose certification has been terminated may be recertified to the former NDT level by a new employer based on examination as described in Section 8, provided all of the following conditions are met to the new employer's satisfaction:

- The employee has proof of prior certification.
- The employee was working in the capacity to which certified within six (6) months of termination.
- The employee is being recertified within six (6) months of termination.
- Prior to being examined for certification, employees not meeting the above requirements should receive additional training as deemed appropriate by the NDT Level III.

Inquiries for SNT-TC-1A, Section 10

NOTE: Inquiries are numbered to include the year of the inquiry and always refer to the edition of *SNT-TC-1A* in effect in that year, unless otherwise stated in the question. *SNT-TC-1A* was published in these years: 1968, 1975, 1980, 1984, 1988, 1992, 1996, 2001.

I. Inquiry 78-4

Inquiry:

- Regarding paragraph 10.2 of *SNT-TC-1A*, does "... based on examination ..." refer to

examinations administered during prior employment or does it refer to new examinations to be administered by the new employer?

2. An individual can provide evidence of prior certification per paragraph 10.2(a), but does not meet either paragraphs 10.2(b) or 10.2(c) which recommend that the individual was working in the capacity to which he had been certified and is being recertified within six months of his termination. What should be the basis of qualification for such an individual?

Response:

1. It is intended that the examination referred to in paragraph 10.2 be administered by the new employer.
2. It is intended that an individual who has neither worked in the capacity to which previously certified in the past six months nor is being recertified within six months should have additional training and experience prior to recertification. The employer's written practice should detail such provisions.

2. Inquiry 78-10

Inquiry:

1. When an employee returns to work for a former employer where he/she was certified, may this employee's certification(s) be reinstated without examination if the provisions of paragraphs 10.2(b) and 10.2(c) are met?
2. If an employee has been continuously working for another employer certified in the same capacities, may his certification(s) be reinstated for the remainder of the original three-year period of certification in accordance with paragraph 9.7?

Response:

1. The provisions of paragraph 10.2 apply only to a new employer. For this part of the inquiry, the provisions of paragraph 9.5.4 would prevail.
2. For this part of the inquiry, the receiving employer would be considered a new employer and the provisions of paragraph 10.2 would apply. If, however, the employee in question was previously

employed by the receiving employer, paragraph 9.7.3 would prevail.

General Comments about *SNT-TC-IA*, Section 10

The principle behind "evidence of continuing satisfactory performance" in paragraph 9.5.1 applies to employees originally certified by and in continuous employment of one employer. It is not envisioned that a new employer should prudently accept evidence of continuing satisfactory performance" from a previous employer. Note that paragraph 10.2 recommends recertification by examination of an employee by a new employer even if the conditions of 10.2.2 and 10.2.3 are met to the new employer's satisfaction. The employer's rules covering the duration of interrupted service (paragraph 9.5.4) should bear a reasonable relationship to the recommendations in paragraph 10.2; however, in the case of interrupted service, the employer has direct knowledge of the employee's prior performance and can best judge the need for reexamination as a function of duration of interrupted service.

Review Questions for *SNT-TC-IA*, Section 10

Q.1-59 Automatic termination of certification is recommended when the certified individual:

- a. terminates employment with the employer where certified.
- b. is temporarily assigned to a different job function.
- c. takes a leave of absence greater than 30 days.
- d. achieves a higher level of certification.

Q.I-60 A certified Level III individual terminates his/her employment with employer A and is immediately employed by employer B. Employer B may certify the individual as Level III based upon which of the following?

- The employer must examine the individual.
- The employer must examine the individual if he/she has not been working as a Level III during the past six months.
- The employer may recertify the individual to Level III, but only after six months of satisfactory service.
- The employer may waive examination if the individual can provide evidence of demonstrated ability, achievement, experience, and education.

Pre-1996 Editions of SNT-TC-1A

The 1996 Edition of *SNT-TC-1A* has been used throughout this study guide as the basis for the administration of a qualification and certification program for NDT personnel.

SNT-TC-1A was first issued in 1968 as a series of five booklets, published separately as *Supplement A: Radiographic Testing Method*, *Supplement B: Magnetic Particle Testing Method*, *Supplement C: Ultrasonic Testing Method*, *Supplement D: Liquid Penetrant Testing Method*, and *Supplement E: Eddy Current Testing Method*. The supplements each contained the main document, the equivalent of paragraphs 1 through 10 of the 1996 Edition. Recommended times for training and experience and certain details, such as the number of examination questions, were contained in each of the different supplements, being somewhat different for each method. In the 1975 Edition, the variable factors were tabulated, thus enabling a single document to contain all of the recommendations under one cover. This format has been retained in later editions.

The pre-1975 supplements also each contained a number of general examination questions that could be used in constructing Level I and Level II examinations. These

questions were not reproduced in the 1975 Edition, but were revised for the 1980 Edition. The supplements to *SNT-TC-1A* contain suggested Level III questions and answers in addition to new and revised Level I and II questions. These supplements provide the individual with excellent study material when preparing for the ASNT NDT Level III examination and they also provide the employer with an excellent guideline for preparing its own examinations.

While the basic principles and approaches recommended in the pre-1975 Editions of *SNT-TC-1A* were essentially unchanged in the 1975, 1980, 1984, 1988, 1992, and 1996 Editions, many details were changed.

Inquiries for Pre-1996 Editions of SNT-TC-1A

1. Inquiry 77-1

Inquiry:

- Is it intended that the 1975 Edition of *SNT-TC-1A* including all recommendations therein completely replace prior editions of *SNT-TC-1A*?
- Is it intended that personnel qualified and certified as recommended in the 1975 Edition of *SNT-TC-1A* be considered equivalent to those qualified and certified as recommended in previous editions of *SNT-TC-1A*?

Response:

The answer is yes to both parts of the inquiry.

2. Inquiry 77-6

Inquiry:

- Is it the intent of *SNT-TC-1A* that Level I, II, and III individuals certified to the recommendations of the 1968 Edition meet the recommendations for certification in the 1975 Edition?
- If certification is transferred from the 1968 Edition to the 1975 Edition recommendations, which recommendations prevail regarding recertification?

Response:

1. It is intended that individuals certified according to the recommendations of earlier editions of *SNT-TC-1A* meet the recommendations for certification in the 1975 Edition.
 2. The 1975 Edition recommendations prevail regarding recertification.
- See also Inquiry 78-2.

Chapter 3

The ASNT Level III Certification Program

Status of the ASNT Level III Certification Program

Beyond the use of *SNT-TC-1A* and prior to the existence of *ASNT CP-189*, members of the Society recognized a need to establish a capability for independently certifying individuals, at least to that of Level III. In 1977, the Society offered Level III examinations for the first time. Examinations administered by ASNT in all methods are now offered four times annually throughout the United States and in nine other countries.

Through January 1996, over 6,000 persons have been certified as an ASNT NDT Level III. The program has received significant international attention.

What is an ASNT NDT Level III?

An ASNT NDT Level III is an individual who assumes the title of NDT Level III, in part, through a screening process offered by the American Society for Nondestructive Testing under the scope of the ASNT NDT Level III Certification Program. The program provides an independent review of a candidate's credentials, followed by the satisfactory completion of two or more comprehensive examinations. The mandatory Basic Examination addresses administrative and general technology knowledge issues, while the Method Examinations address an in-depth knowledge of the theory and practices of eleven nondestructive testing methods.

The Society provides the examination service for aspiring ASNT NDT Level III personnel four times a year at various locations throughout the United States. Examinations are also offered in foreign locations on an as-needed basis.

The general requirements for admission to the examinations include:

1. Satisfaction of one of the following criteria regarding education and progressive NDT experience:
 - a. Graduation with a degree in engineering, physics or science from a four-year college or university curriculum plus one year's experience in NDT in an assignment at least comparable to that of a Level II inspector in the applicable test method(s), or;
 - b. Completion of at least two years of engineering or science study at a university, college, or technical school with passing grades plus two years experience in an assignment at least comparable to that of an NDT Level II inspector in the applicable test method(s), or;
 - c. Possession of four years of experience in an assignment at least comparable to that of an NDT Level II inspector in the applicable test method(s).

Note: Applicants must document their claimed education and describe and verify their NDT experience.
2. Applicants must agree to acknowledge and abide by the *ASNT Code of Ethics for Level III NDT Personnel*, which is found in Appendix 1.
 - a. An ASNT NDT Level III certificate is given to candidates who successfully pass the screening process and the written examinations. The certificate remains in effect for five (5) years and is a reflection of the capabilities of the individual, irrespective of where they may be employed. The certificate is most easily renewed by reapplying to ASNT before the five-year period expires, describing and

documenting activities done in support of advancing one's knowledge with the NDT technologies and demonstrating evidence of on-going active employment in the field.

Note: Some clients and agencies require recertification be satisfied through reexamination.

ASNT Level III Examinations

A detailed outline of the subject matter covered, study references, and sample questions are sent to each person requesting an application.

The Basic Examination covers the administration of *SNT-TC-1A* and *CP-189*, materials, fabrication and product technology (general knowledge), and general principles and applications of commonly used NDT methods.

The Method Examination addresses an NDT method and includes method fundamentals and principles, the establishment of method techniques, and the interpretation of codes, standards, and specifications relating to the method.

The Basic Examination is given to all applicants regardless of the methods for which they seek certification. The Method Examination is given according to the applicant's request in one or more of the following methods:

1. Acoustic emission testing (AE)
2. Electromagnetic testing (ET)
3. Infrared/Thermal testing (IR)
4. Leak testing (LT)
5. Liquid penetrant testing (PT)
6. Magnetic particle testing (MT)
7. Neutron radiographic testing (NR)
8. Radiographic testing (RT)
9. Ultrasonic testing (UT)
10. Vibration and analysis testing (VA)
11. Visual and optical testing (VT)

The examination questions are in an objective, multiple-choice format. Some questions require analysis and computations while others test for factual knowledge. All examinations are closed book tests. Where reference information is needed, it is included in the body of the examination. Trigonometric

tables, logarithmic tables, etc., are furnished with the examinations, if necessary.

Parts of the Method Examinations cover practical usage of charts, graphs, and other material typically encountered in NDT practice. A document that applies generally to the method is also included in the body of the examination and questions are asked about its interpretation. The document is not specific to any particular product or product group nor does it relate to any particular industrial segment.

Use of the ASNT NDT Level III Certification

The ASNT NDT Level III Certification has become a recognized way for individuals, companies and industry sectors to take advantage of the integrity inherent in the use of a professional third party to attest authoritatively to an individual's preparedness to lead and administer the NDT programs within testing services, manufacturing organizations, and safety-sensitive special-interest groups.

But because there are many differences in the details used in each group to achieve their performance goals, the ASNT NDT Level III program only addresses the most general aspects of each method's characteristics.

Note: In the case of *ANSI/ASNT CP-189*, an individual must hold an ASNT NDT Level III certificate prior to becoming an organization's Level III. In the case of *SNT-TC-1A*, an individual can use the ASNT NDT Level III certificate as one of the many optional approaches for becoming an organization's Level III. But in both cases, the ASNT NDT Level III certificate must be augmented with a written practice that identifies, in detail, the manner by which the organization's Level III is qualified and certified for the specific purposes of the organization.

In order to explain the intended relationship as to how the ASNT NDT Level III certificate can be used with the written practice of an employer under the *Recommended Practice No. SNT-TC-1A*, the following excerpts from an ASNT Board of Directors Position Paper, published in *Materials Evaluation* in July 1980, are offered for clarification.

"The following is the official ASNT position on the use and application of ASNT *Recommended Practice No. SNT-TC-1A* (1980 Edition), *Personnel Qualification and Certification in Nondestructive Testing* and the ASNT Level III Certification Program.

"... *SNT-TC-1A* is published to serve as a guideline to employers in establishing their own written practice for the qualification and certification of their NDT personnel. It is not intended to be a strict specification. The intent is to provide guidelines for proficiency levels required for personnel involved in nondestructive testing ...

"... The Board of Directors, in establishing the ASNT Level III Certification Program, offered to employers an optional service, which is consistent with Level III qualification recommendations of *SNT-TC-1A*. Further, certification by ASNT was defined to be "a certification that the records of an individual indicate attainment of the qualifications required by Part A of the program, or satisfactory completion of a written examination under Part E of the program.

"The official position on ASNT Level III certification is as follows:

1. The ASNT Level III certification program is in compliance with *SNT-TC-1A* guidelines.
2. Individuals certified to Level III in any NDT method by ASNT are considered to have met the guidelines of *SNT-TC-1A* (Basic Examination and Method Examination). Where proof of experience exists, and is documented with or without examination, in the preparation of acceptable NDT procedures, codes, standards and specifications and in the evaluation of the test results, and is acceptable under the buyer-seller agreement, then the individual shall be considered to have met the guidelines of *SNT-TC-1A* (Specific Examination)."

Certification Options

SNT-TC-1A offers the employer several options for fulfilling certification responsibilities:

1. incorporate acceptance of an ASNT Level III certification into the

2. employer's own written practice; incorporate acceptance of a Level III's qualifications using an outside agency acceptable to the employer's clientele in the employer's written practice; or
3. incorporate the employer's own documented examination program acceptable to their clientele in the written practice.

Recertification

The recertification plan by application (for an ASNT NDT Level III) requires that "each certificate holder demonstrate:

1. at least a minimal effort to remain current, i.e., keep abreast of changes in the technology of the methods for which recertification is sought; and,
2. continued active engagement in a Level III occupation."

Detailed information required for recertification by application is available from ASNT headquarters. In general, recertification can be obtained by application subject to the following conditions:

1. reaffirmation of the *ASNT Code of Ethics for Level III NDT Personnel*;
2. continued active employment in Level III functions as related to the NDT method(s) for which recertification is sought. (Thirty-six months of the typical 60-month certification period, not necessarily consecutively, but with at least 12 of the last 24 months working in a Level III function immediately preceding certification expiration.) Where the work experience did not include all methods for which recertification is sought, at least two additional "points" (see below) shall be obtained in each method for which there was no work experience; and
3. continued active effort to keep up-to-date and/or contribute to NDT-related knowledge by obtaining a minimum of six (6) "points" during each of the five-year period of certification through engaging in one or more of the following activities:
 - a. author presentations at society meetings - 2 points,

- b. publish papers in technical journals - 3 points,
- c. attend technical sessions (e.g., Section) - 1 point,
- d. present courses for credit (2 contact hours) - 1 point, and
- e. complete courses for credit (each CEU) - 1 point.

Inquiries for ASNT Level III Certification

The foremost misconception about the ASNT Level III certification was that it was intended to replace employer-based certification. The ASNT Level III certification, from the outset, was defined to be:

"a certification that the records of an individual indicate satisfactory completion of a written examination.

"Individuals certified to Level III in any NDT method by ASNT are considered to have met the guidelines of *SNT-TC-IA* 8.8.1 (Basic Examination) and 8.8.2 (Method Examination). Where proof of experience exists, and is documented with or without examination, in the preparation of acceptable NDT procedures, codes, standards and specifications and in the evaluation of the test results, and is acceptable under the buyer-seller agreement, then the individual shall be considered to have met the guidelines of *SNT-TC-IA* paragraph 8.8.3(b) (Specific Examination)."

The ASNT Level III examinations are clearly at least as effective in qualifying Level III NDT personnel as the majority of employer-based examinations and examinations offered by other outside services. (In comparison to the *SNT-TC-IA* recommendations for an ultrasonic method Level III, an ASNT Level III examination requires 135 questions, while *SNT-TC-IA* recommends 65 questions. Similarly, an ASNT Level III Basic Examination requires 135 questions, while *SNT-TC-IA* recommends 55 questions. The ASNT examinations were purposely designed to fulfill the recommendations of *SNT-TC-IA* for the Level III Basic Examination and Method examination. While the ASNT Level III examinations are quite broad and comprehensive, the employer's responsibilities in developing a Specific Examination are

obvious. In effect, if the Specific Examination truly covers the "employer's procedural requirements" as stated in *SNT-TC-IA*, each employer's Specific Examination will be different from any other employer. Outside services can be commissioned to develop specific examinations tailored to individual employers' needs.

Another area of misconception existed with regard to factoring ASNT Level III examination scores into the composite grade referred to in *SNT-TC-IA*. Prior to initiating the ASNT Level III examination program, it was specified by ASNT that the certification program's examination records would not be subject to review or audit by anyone. Hence, applicants are informed only of pass/fail status. This policy led to the following inquiry:

Inquiry:

Level III personnel certified by ASNT do not receive examination grades. *SNT-TC-IA* recommends arriving at a composite grade. How can this be accomplished since ASNT only supplies examination results in terms of pass or fail?

Response:

The 1992 Edition of *SNT-TC-IA* addresses this matter in paragraph 8.1.4, "When an examination is administered and graded for the employer by an outside agency, and the outside agency issues grades of Pass or Fail only, on a certified report, then the employer may accept the Pass grade as 80 percent for that particular examination."

Current ASNT Basic Examinations do not contain questions relating specifically to the ASNT Level III certification program. The ASNT Level III certification program is no more than a service offered to employers and individuals to be examined by an outside agency in accordance with *SNT-TC-IA*. It provides one of the available options toward Level III qualification and certification. Note, however, that it is mandated by *ANSI/ASNT CP-189*. Fundamental in both documents is the concept that "certification of all levels of NDT personnel is the responsibility of the employer." (This is stated in paragraph 9.1 of *SNT-TC-IA*). Its comparable statement, "The employer shall develop and maintain a procedure detailing the program that will be used for qualification and

certification of NDT personnel in accordance with this standard" is found in paragraph 5.1 of *ANSI/ASNT CP-189*.

Review Questions

- Q.1-61 The ASNT NDT Level III certification program is mandated under the requirements of:
- SNT-TC-1A*, 1992 Edition.
 - ASNT CP-189* (1995).
 - both of the above.
 - none of the above.
- Q.1-62 An ASNT NDT Level III is an individual who assumes the title of NDT Level III, in part, through:
- a screening process by an impartial third party.
 - satisfactory completion of a Basic Examination on administrative and general technology knowledge.
 - satisfactory completion of a Method Examination addressing in-depth knowledge of the theory and practices of the chosen method.
 - all of the above.
- Q.1-63 The title of ASNT NDT Level III is granted by:
- ASNT and makes an individual immediately qualified to become an employer's Level III.
 - ASNT and makes an individual potentially eligible to become an employer's Level III.
 - ASNT and automatically permits the individual to function as an independent Level III.
 - ASNT and only applies when recognized by some requirements document.
- Q.1-64 The ASNT NDT Level III certificate, as issued, remains in effect for five years. Its renewal after the five years is accomplished by:
- showing evidence of being continually employed in the field of NDT throughout the interim period.
 - showing evidence of extra efforts aimed at advancing one's knowledge of NDT technologies in each of the intervening years.
 - showing continued effectiveness by retaking the Basic Examination and the Method(s) Examination(s).
 - none of the above.
- Q.1-65 The Method Examination covers:
- recognition of and use of equations.
 - interpretation of charts and graphs.
 - interpretations and use of a sample procedure.
 - all of the above.
- Q.1-66 Individuals certified to ASNT NDT Level III are considered to have met the:
- employer's written practice requirements.
 - requirements of *ANSI/ASNT CP-189*.
 - requirements of the *ASME Boiler and Pressure Vessel Code*.
 - guidelines of *SNT-TC-1A* (Basic and Method Examinations).
- Q.1-67 Individuals considering certification as an ASNT NDT Level III, in general, must be:
- well-rounded with a broad understanding of the theory and application of many methods
 - knowledgeable in their respective method, since now they will be considered experts in the method.
 - familiar with statistical interpretations of in-process control data.
 - able to interpret technical articles, even if written in a foreign language.

Chapter 4

ASNT CP-189 (1995)

(Formerly ANSI/ASNT CP-189 (1995))

Overview of ASNT CP-189

The abstract of *ASNT CP-189 (1995)* contains the following statements. "This standard applies to personnel whose specific tasks or jobs require appropriate knowledge of the technical principles underlying nondestructive testing (NDT) methods for which they have responsibilities with the scope of their employment. These specific tasks or jobs include, but are not limited to, performing, specifying, reviewing, monitoring, supervising, and evaluating NDT work.

"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 process of personnel qualification and certification as detailed in the standard does not relieve the employer of the ultimate legal responsibility to ensure that the NDT personnel are fully qualified for the tasks being undertaken."

These statements define who is under the jurisdiction of the standard and state that the ultimate responsibility of the qualification and certification process remains with the employer. The fact that *CP-189* is an American National Standard signifies that the requirements for due process, consensus, and other criteria as defined by the American National Standards Institute (ANSI) have been met by the standard developer, in this case, The American Society for Nondestructive Testing, Inc.

The first paragraph of *CP-189* reads as follows:

1. Scope

- 1.1 This standard establishes the minimum requirements for the qualification and certification of nondestructive testing (NDT) personnel.
- 1.2 This standard details the minimum training, education, and experience requirements for

NDT personnel and provides criteria for documenting qualifications and certification.

- 1.3 This standard requires the employer to establish a procedure for the certification of NDT personnel.
- 1.4 This standard requires that the employer incorporate any unique or additional requirements in the certification procedure.

It is clear that the tone of this document is distinctly more regimented than the scope of *SNT-TC-1A*, which states that "this document provides guidelines for the establishment of a qualification and certification program" and "it is recognized that these guidelines may not be appropriate for certain employers' circumstances and/or applications." The standard demands that a minimum set of requirements be met by all employers who claim to have a program that embraces the standard.

The following comments are intended to amplify on the differences and similarities between the standard, *CP-189*, and the recommended practice, *SNT-TC-1A*.

In 2., *Definitions*, of *CP-189*, nineteen definitions are listed to remove any ambiguity about terms used throughout the body of the standard. A distinction is made between "evaluation" (a determination of the significance of a relevant indication) and "interpretation" (the determination of whether indications are relevant, or nonrelevant) as applied to NDT test data. The term "NDT instructor" (an individual qualified and designated in accordance with this standard to train or educate NDT personnel) is introduced. The term "Practical Examination" is clarified in its use on behalf of the employer and the fact that observations and results must be documented. "Test technique" (a category within an NDT method; for example, immersion ultrasonic testing) is distinguished

from "method" (one of the disciplines of NDT; for example, ultrasonic testing).

In paragraph 2.2, an "NDT Level III" is identified as "an individual possessing a currently valid ASNT NDT Level III certificate and certified in accordance with this standard." Thus, in order to become an employer's NDT Level III, *CP-189* mandates that the individual hold a currently valid ASNT NDT Level III certificate. Other requirements must be customized to the needs of the employer in accordance with the employer's written NDT personnel qualification and certification procedure.

In paragraph 3., *Levels of Qualification*, the five levels of qualification are defined in terms of the skill and knowledge required in a given method or methods to perform specified NDT activities. These are Levels I, II, and III plus Trainee and NDT Instructor. The first three are nominally the same as those identified in *SNT-TC-1A*. The last two formalize the status of the trainees and create a category of NDT instructor who can function as course organizer and presenter, but under the cognizance of the employer's authorized (certified) Level III.

In paragraph 4., *Qualification Requirements*, addresses training, experience and the use of outside NDT Level III services. The training is to be done in accordance with the course outline in Appendix B of *CP-189* for the appropriate method. The outline used is to be approved, and possibly expanded upon, by the employer's NDT Level III. The training programs shall include sufficient examinations to demonstrate that the necessary information has been comprehended. A satisfactory passing score on a final examination is necessary in order to receive credit for the training hours. A comparison of the minimum number of hours of classroom training required for Level I and Level II candidates for *SNT-TC-1A* and *CP-189* is compared in Table 4.

In most cases, the training hour requirements of *CP-189* agree with those recommended for a high school graduate as per *SNT-TC-1A*, however, differences occur for ET (Level I - 12 hours vs. 40 hours), PT (Level I - 8 hours vs. 4 hours) and VT (Level II - 12 hours vs. 16 hours). *SNT-TC-1A* generally suggests fewer initial training hours for personnel with 2 years of supplemental technical education with the exception of Level II in AE, ET, NR and UT.

Table 4: Initial training hours comparison

Method	Level	Technique	CP-189 (Hours)	SNT-TC-1A (Hours) (High School)	SNT-TC-1A (Hours) (2-year College)
AE	I		40	40	12
	II		40	40	40
ET	I		12	40	24
	II		40	40	40
LT	I	HT	4	2	2
	II		2	4	2
	I	PCT	24	24	16
	II		16	16	12
	I	HDLI	12	12	8
	II		8	8	6
	I	MSLT	40	40	28
	II		24	24	16
MT	I		12	12	8
	II		8	8	4
NR	I		28	28	20
	II		40	40	40
PT	I		8	4	4
	II		8	8	4
RT	I		40	39	29
	II		40	40	35
IR	I		40	40	36
	II		40	40	35
UT	I		40	40	30
	II		40	40	40
VA	I		24	24	24
	II		80	80	56
VT	I		8	8	4
	II		12	16	8

Recognizing that NDT is a unique application of the concepts of physics, electronics, and chemistry, *CP-189* requires that all training shall be presented by an NDT instructor designated by the NDT Level III individual. The NDT Instructor is an individual not only that has the skills and knowledge for conducting training programs, but also who is required to develop and conduct such courses in accordance with the course outlines approved by an NDT Level III. The NDT Level III in all cases is responsible for the content of each completed course. In order to qualify, an NDT Instructor must satisfy at least one of the following criteria:

1. possess a current ASNT NDT Level III certificate in the method being taught.
2. have academic credentials equivalent to a B.Sc. in technology with knowledge of the NDT method.
3. have graduated from a two-year science school and have five years of experience as an NDT Level II.
4. have ten years of experience as an NDT Level II in the method to be taught.

Training and experience qualifications of the NDT Level III are automatically met when they hold a valid ASNT NDT Level III certificate.

The required experience for Level I and Level II personnel per *CP-189* are compared with the recommendations of *SNT-TC-1A* in Table 5. Note that *CP-189* calls for a minimum number of hours worked in the specific method as well as a minimum total number of hours worked in NDT. The total requirement can be satisfied by working in two or more methods as well as doing other activities that support the NDT program of the employer. Note that *SNT-TC-1A* expresses experience in terms of months.

When using *CP-189*, it is important to note that the required minimum experience hours must be documented, by method and by hour, with supervisor or NDT Level III approval. A candidate's previous training and experience may be accepted by the employer if verified and documented in writing by the previous employer(s) or training agencies.

Although employers often have their own NDT Level III to administer the various aspects of the employer's NDT personnel qualification

and certification program, an outside organization may be engaged to perform the duties of an NDT Level III. In such instances, the employer is responsible for verifying that the organization complies with the employer's certification procedure and *CP-189*.

The employer's certification procedure describes the minimum requirements for certifying personnel in each NDT method and is approved by the designated NDT Level III. The procedure includes personnel duties and responsibilities, as well as the required training, experience, examinations, records and recertification processes to be followed.

In paragraph 6., *Examinations*, the examinations found in *CP-189* are compared to those of *SNT-TC-1A*. Both are similar but they have some minor differences. The near-distance vision examination calls for an individual to be capable of reading a Jaeger Number 1 test chart at a distance of 30.5 cm (12 in.), rather than the Jaeger Number 2 of *SNT-TC-1A*, and to be administered in accordance with a procedure, and by personnel, approved by the designated NDT Level III.

Level I and Level II personnel are to receive a closed book general examination approved by the designated NDT Level III over a cross section of the body of knowledge applicable to each method and NDT level. The minimum number of questions required is the same as that recommended by *SNT-TC-1A* with the absence of anything regarding the Infrared/Thermal testing method.

Level I and Level II personnel are to receive a closed book specific examination, supported by NDT Level III approved reference materials, addressing various examples of equipment, procedures, and test techniques that the candidate may use in the performance of assigned duties. The minimum number of questions required is the same as that recommended by *SNT-TC-1A* with the exception of ET, which has ten extra Level I questions.

The Level I Practical Examination requires that the candidate demonstrate proficiency in using the applicable NDT method to examine one or more representative test samples for each technique to be used in the candidate's job. This includes the documentation of the results of the test(s).

The Level II Practical Examination requires that the candidate demonstrate proficiency

Table 5: Experience needed for qualification (CP-189 vs. SNT-TC-1A)

Method	Level	Technique	Method (Hours)	Total NDT (Hours)	SNT-TC-1A (Months)
AE	I		200	400	3/210
	II		600	1200	9/630
ET	I		65	130	3/210
	II		600	1200	9/630
LT	I	BT	7.5	15	*3
	II		40	80	0.5/35
	I	PCT	100	200	1.5/105
	II		265	530	4/280
	I	HDLT	100	200	1.5/105
	II		265	530	4/280
	I	MSLT	265	530	4/280
	II		400	800	6/420
MT	I		65	130	1/70
	II		200	400	3/210
NR	I		400	800	6/420
	II		1200	2400	24/1680
PT	I		65	130	1/70
	II		135	270	2/140
RT	I		200	400	3/210
	II		600	1200	9/630
IR	I				3/210
	II				18/1260
UT	I		200	400	3/210
	II		600	1200	9/630
VA	I				6/420
	II				24/1680
VT	I		65	130	1/70
	II		130	270	2/140

using the applicable NDT method to examine two or more representative test samples for each method and at least one sample for each technique to be used in the candidate's job. This includes the interpretation, evaluation, and documentation of the examination's results.

The Level I Practical Examination and the Level II Practical Examination are similar to those recommended by *SNT-TC-1A*, with the exception of demonstrating each technique and using test samples that are representative of expected production parts. This difference forces the CP-189 examinations to be more realistic to the typical manufacturing or in-service workplace.

More explicit examination requirements have been placed on the NDT Level III due to the many variations in background and work activities found in the field. As a prerequisite, a candidate for the position of an employer's Level III must hold an ASNT NDT Level III certificate with a currently valid endorsement for each method for which employer certification is sought, and he/she must also satisfactorily complete an employer-prepared, thirty (30) question specific examination on the employer's specifications and standards for each method. A valid endorsement on an ASNT NDT Level III certificate fulfills the examination criteria for only the Basic Examination and the Method Examination for each applicable NDT method.

In addition, the candidate may have to show his/her ability to prepare an NDT procedure appropriate to the employer's needs, if he/she does not have documented experience demonstrating that they had previously prepared similar procedures in the method using the specifications, codes, and standards that are applicable to that employer.

If the NDT Level III will be required to perform tests or evaluate test results, the candidate must demonstrate an ability to perform the required activities.

The employer's NDT Level III is responsible for the administration and grading of the examinations, but the grading and administration of multiple-choice objective questions can be delegated when properly documented. The practical is to be administered by an NDT Level III in the respective test method. The employer is responsible for having an ASNT NDT Level III develop, administer, and grade the Level III

Specific and Practical Examinations. Employer examinations require a 70 percent on individual tests and an 80 percent on the overall average grade.

For a Level I or Level II candidate to pass the Practical Examination, discontinuities or conditions previously specified by the Level III are to be located and evaluated. A written checklist, addressing equipment and technique proficiency, is to be used following the procedure, test sequence, calibrations, materials, documentation, and extent of examination. If interpretation or evaluation of results is included, these are to also be part of the checklist. In addition, the Level II list includes proper extent of examination, accuracy and completeness of interpretations, evaluations, and documentation of the activities and test results. The Level III Practical Examinations shall also use a written checklist that addresses items relating to the technical and practical adequacy of the NDT procedure(s) prepared by the candidate.

If an examination is failed, reexamination is similar to *SNT-TC-1A* (wait 30 days or receive directed training), except that a candidate is not to be reexamined using the examination and/or specimen previously failed.

The employer's representative who administers the Level III examinations must possess a current ASNT NDT Level III certificate in the method and be familiar with the standards used and the products made by the employer. Self-examination and examination by subordinates is prohibited.

In paragraph 7, *Addresses Expiration, Suspension, Revocation, and Reinstatement of Employer Certifications*. As with *SNT-TC-1A*, an individual's certification(s) expire when employment with the employer is terminated or at the end of three years for Levels I/II. The Level III certification expires when the ASNT NDT Level III certificate has expired.

Certifications can be suspended for exceeding the 1-year vision recheck period, for inactivity in a method for more than 12 months, or for deficient performance as determined by the Level III. Level IIIs are suspended if their ASNT Level III certificate is not renewed.

Certifications are revoked if inactivity in a method exceeds 24 months, if the ASNT NDT Level III certificate is revoked or if there is unethical or incompetent conduct.

Reinstatement for Level I and Level II is determined by the Level III. Reinstatement for the Level III is determined by the employer as long as the Level III holds a valid ASNT Level III certificate. Expired or revoked certifications may only be reinstated by complying with section 6.

In 8, *Employer Recertification*, recertification relies on paragraph 6 for Level I and Level II and verification of the currency of the Level III's ASNT certificate every five years.

In 9, *Records*, a minimum set of documents that address the qualifications of each NDT individual is required. Included are a certification record, an experience record, a record of previous experience (if applicable), and a record of a current vision examination.

The certification record includes level, method and technique(s), results and copies of recent examinations, a copy of current ASNT Level III certificate, and the signature of employer's certifying representative.

A training record is required that includes the training received, the name of the training organization, the date when training was completed, the hours involved, evidence of satisfactory completion, and the instructor's name.

A record that identifies the individual's experience performing various nondestructive tests shall be maintained for the purpose of verifying initial certification experience and continuing experience. Previous experience

shall also be documented if it is used to satisfy any part of the qualification requirements. Table 6 compares the qualifications of an Ultrasonic Testing Level III according to *SNT-TC-1A*, *CP-189* and the ASNT Level III certification program.

Review Questions

Q.I-68 In accordance with *ASNT CP-189* (1995), the NDT Level III shall be responsible for:

- grading individual certification examinations.
- preparing training materials for NDT Level I and Level II personnel.
- approving all questions to be used on examinations for Level I and Level II.
- all of the above.

Q.I-69 Which of the following may conduct and grade examinations for Level I and Level II personnel?

- An NDT Level III.
- A documented representative of the NDT Level III.
- A contracted outside agency.
- All of the above.
- Both a and b.

**Table 6: Comparison of qualifications
(NDT Level III, ultrasonic testing)**

	<i>SNT-TC-1A</i>	ASNT Level III	<i>CP-189</i>
Initial Credentials			
Education (College)	4 yr 2 yr 0 yr	4 yr 2 yr 0 yr	ASNT Level III
Supplemental Training	- - -	- - -	
Experience (Equiv. - II)	1 yr - 2 yr - 4 yr	1 yr 2 yr 4 yr	
Examinations (number of Questions)			
Basic	55	135	ASNT Level III
Method	65	135	ASNT Level III
Specific	20	-	30
Practical	-	-	Procedure Preparation or Experience
Demo	-	-	(IF testing)
Administrator	-	ASNT Staff	ASNT Level III
Requalification	5 years of Satisfactory Performance	5 years of Application or Reexamination	5 years of Current ASNT Certification

- Q.1-70 When the near-distance, visual acuity examination is given using the reading card with Jaeger letters, it must be given:
- in accordance with a procedure.
 - by a person approved by the NDT Level III.
 - at least once a year.
 - by all of the above.
- Q.1-71 As required in *ASNT CP-189*, Level I practical examinations are intended to be:
- given by the employer's Level III.
 - graded by the employer's Level III.
 - given using one or more test samples for each technique.
 - given using one or more test samples for each method.
 - passed only if all predefined discontinuities are detected and evaluated.
- Q.1-72 The Practical Examination shall address the technical and practical competency of the examinee when following prepared NDT procedures for:
- Levels I, II, and NDT instructor.
 - Levels I and II.
 - corporate Level IIIs.
 - all of the above.
- Q.1-73 The Practical Examination shall address the technical and practical competency of the examinee when following prepared NDT procedures for:
- Levels I, II, and III.
 - Levels I and II.
 - Level III.
 - Level III and NDT instructors.
 - all of the above.
- Q.1-74 The employer's Level III is responsible for certification of:
- Levels I and II.
 - outside inspection services and consultants.
 - other Level IIIs within the organization.
 - all of the above.
 - none of the above.

Section 2

Section 2

Section 2

General Application of Various NDT Methods

References

- Ness, Stanley and Charles N. Sherlock, technical eds.; Paul McIntire and Patrick O. Moore, eds.
Nondestructive Testing Handbook, second edition: Volume 10, *Nondestructive Testing Overview*. Columbus, OH: The American Society for Nondestructive Testing, Inc. 1996.*
- ASM Metals Handbook*, 9th edition, Volume 17, *Nondestructive Evaluation and Quality Control*.
Metals Park, OH: ASM International. 1989.*

*This reference is available from ASNT.

کتابخانه مرکزی
کتابخانه مرکزی
84, 4, 81, 563, 5

Chapter 5

General Applications of Various NDT Methods

Overview of the ASNT Basic Examination

The second part of the ASNT Basic Examination for Level III Certification covers the examinee's knowledge and comprehension of basic and fundamental applications of all methods of NDT. While an employer's current requirements for a Level III may only involve one, or two, or a few NDT methods, it is not envisioned that a Level III as described in Paragraph 4.3.3 of *SNT-TC-1A* can function adequately without some basic knowledge of the existence and applications of all commonly used NDT methods.

In light of rapidly expanding technology, Level III NDT personnel have an obligation to continually review current practices, recommend and develop new techniques where applicable, and seek more effective methods where applicable. Without some basic knowledge of the broad applications aspects of NDT Technology, the NDT Level III could not be considered to meet the Level III qualifications as defined in *SNT-TC-1A*, Paragraph 4.3.3: "capable of establishing techniques and procedures; interpreting codes, standards, specifications, and procedures; and designating the particular NDT methods, techniques, and procedures to be used. The NDT Level III should be responsible for the NDT operations for which qualified and assigned and should be capable of interpreting and evaluating results in terms of existing codes, standards, and specifications. The NDT Level III should have sufficient practical background in applicable materials, fabrication, and product technology to establish techniques and to assist in establishing acceptance criteria where none are otherwise available. The NDT Level III should have general familiarity with other appropriate NDT methods as demonstrated by the ASNT Level III Basic Examination or other means. The NDT Level III, in the methods in which certified,

should be capable of training and examining NDT Level I and Level II personnel for certification in those methods."

Topical Outlines, Reference Resources, and Review Questions

This section contains topical outlines, reference resources and review questions for the official NDT methods recognized in *SNT-TC-1A*. The reader is advised to use the reference resource material if difficulty is encountered in answering the following questions. Note especially that the questions are not difficult for those with practical exposure in the use of the method. The questions are devised to cover fundamentals, basic techniques, and applications.

Acoustic Emission Testing (AE)

Topical Outline

- 1.0 Fundamentals
 - 1.1 Principles/theory of acoustic emission
 - 1.2 Sources of acoustic emissions
 - 1.3 Equipment and material
- 2.0 Proper selection of acoustic emission technique
 - 2.1 Instrumentation and signal processing
 - a. Cables (types)
 - b. Signal conditioning
 - c. Signal detection
 - d. Noise discrimination
 - e. Electronic technique
 - f. Attenuation materials
 - g. Data filtering techniques
- 3.0 Interpretation and evaluation of test results

Reference

Miller, Ronnie K., technical ed., Paul McIntire, ed. *Nondestructive Testing Handbook*, second edition: Volume 5, *Acoustic*

Emission Testing, Columbus, OH: The American Society for Nondestructive Testing, Inc. 1987.

Review Questions

- AE-1 The most common range of acoustic emission testing is:
- 10-15 KHz.
 - 100-300 KHz.
 - 500-750 KHz.
 - 1-5 mHz.
- AE-2 Discontinuities that are readily detectable by acoustic emission testing are:
- leaks.
 - plastic deformation.
 - growing cracks.
 - all of the above.
- AE-3 The total energy loss of a propagating wave is called:
- scatter.
 - dispersion.
 - diffraction.
 - attenuation.
- AE-4 The Kaiser effect refers to:
- velocity changes due to temperature changes.
 - low amplitude emissions from aluminum structures.
 - the behavior where emission from a source will not occur until the previous load is exceeded.
 - none of the above.
- AE-5 The felicity effect is useful in evaluating:
- fiber-reinforced plastic components.
 - high alloy castings.
 - large structural steel members.
 - ceramics.
- AE-6 The Kaiser effect is useful in distinguishing:
- electrical noise from mechanical noise.
 - electrical noise from growing discontinuities.
 - mechanical noise from growing discontinuities.
 - electrical noise from continuous emissions.
- AE-7 The term "counts" refers to:
- the number of times a signal crosses a preset threshold.
 - the number of events from a source.
 - the number of transducers required to perform a test.
 - none of the above.
- AE-8 The acoustic emission signal amplitude is related to:
- the preset threshold.
 - the intensity of the source.
 - the band pass filters.
 - background noises.
- AE-9 Threshold settings are determined by:
- the graininess of the material.
 - the attenuation of the material.
 - the test duration.
 - the background noise level.
- AE-10 Background noise can be reduced by:
- electronic filtering.
 - using flat response amplifiers.
 - using in-line amplifiers.
 - using heavier gage coaxial cable.

Electromagnetic Testing (ET)

Topical Outline

- Fundamentals
 - Electromagnetic field generation
 - Properties of eddy current
 - Effects of varying frequency
 - Phase discrimination
- Electromagnetic Testing
 - Sensors

- 2.2 Basic types of equipment; types of read-out
- 2.3 Reference standards
- 2.4 Applications and test result interpretation
 - a. Flaw detection
 - b. Conductivity and permeability sorting
 - c. Thickness gaging
 - d. Process control

Reference

Mester, Michael L., technical ed., Paul McIntire, ed. Volume 4. *Electromagnetic Testing*. Columbus, OH: The American Society for Nondestructive Testing, Inc. 1986.

Review Questions

- ET-1 Eddy currents are circulating electrical currents induced in conductive materials by:
- a. continuous direct current.
 - b. gamma rays.
 - c. an alternating magnetic field.
 - d. a piezoelectric force.
 - e. any of the above.
- ET-2 The method used to generate eddy currents in a test specimen by means of a coil can most closely be compared with the action of a:
- a. transformer.
 - b. capacitor.
 - c. storage battery.
 - d. generator.
 - e. resistor.
- ET-3 Eddy current testing relies on the principle of:
- a. magnetostriction.
 - b. electromagnetic induction.
 - c. piezoelectric energy conversion.
 - d. magnetomotive force.
 - e. direct current flow in a resistive circuit.
- ET-4 When the electrical current in an eddy current coil reverses direction, the:
- a. direction of the eddy currents in a part remains the same.
 - b. eddy currents in the test part will change phase by 45°.
 - c. direction of the eddy currents in the part also reverses.
 - d. eddy currents in the part remain the same.
- ET-5 In order to generate measurable eddy currents in a test specimen, the specimen must be:
- a. an electrical conductor.
 - b. an electrical insulator.
 - c. either a conductor or insulator.
 - d. a ferromagnetic material.
 - e. a nonmagnetic material.
- ET-6 The magnetic field generated by eddy currents induced in a test specimen:
- a. opposes the magnetic field that induced the eddy currents.
 - b. reinforces the magnetic field that induced the eddy currents.
 - c. cancels the magnetic field that induced the eddy currents.
 - d. has no effect on the magnetic field that induced the eddy currents.
- ET-7 In eddy current testing, IACS is a recognized abbreviation for:
- a. Induced Alternating Current System.
 - b. Inductively Activated Comparison System.
 - c. Internal Applied Current System.
 - d. International Annealed Copper Standard.
- ET-8 In eddy current testing, the specimen is coupled to the test coil by:
- a. core coupling.
 - b. magnetic saturation.
 - c. the coil's electromagnetic fields.
 - d. magnetic domains.
 - e. dry powder couplants.

- ET-9 The penetration of eddy currents in a conductive material is decreased when the:
- test frequency or conductivity of the specimen is decreased.
 - test frequency is decreased or conductivity of the specimen is increased.
 - test frequency, conductivity of the specimen, or permeability of the specimen is increased.
 - permeability of the specimen is decreased.
- ET-10 At a fixed test frequency, in which of the following materials will the eddy current penetration be greatest?
- aluminum (35% IACS conductivity).
 - brass (15% IACS conductivity).
 - copper (95% IACS conductivity).
 - lead (7% IACS conductivity).
- ET-11 A term used to describe the effect observed due to a change in the coupling between a test specimen and a flat probe coil when the distance of separation between them is varied is:
- fill factor.
 - edge effect.
 - end effect.
 - lift-off.
 - coupling loss.
- ET-12 When testing with eddy currents, discontinuities will be most easily detected when the eddy currents are:
- coplanar with the major dimension of the discontinuity.
 - perpendicular to the major plane of the discontinuity.
 - parallel to the major dimension of the discontinuity.
 - 90° out of phase with the current in the coil.
- ET-13 Which of the following discontinuities are easiest to detect with an eddy current test? (Assume that the area of the discontinuity is equal in all 5 choices listed.)
- A subsurface crack which lies parallel to the direction of the eddy current.
 - A discontinuity located in the center of a 51 mm (2 in.) diameter bar.
 - A radial crack that extends to the outer surface of a 51 mm (2 in.) diameter bar.
 - A subsurface radial crack located at a depth of 13 mm (0.5 in.) in a 51 mm (2 in.) diameter bar.
 - A surface crack that lies parallel to the direction of the eddy current.
- ET-14 A term used to define the timing relationships involved in alternating current signals is:
- magnitude.
 - phase.
 - impedance.
 - reactance.
 - time-gain correction.
- ET-15 The impedance of a test coil can be represented by the vector sum of:
- inductive reactance and resistance.
 - capacitive reactance and resistance.
 - inductive reactance and capacitive reactance.
 - inductive reactance, capacitive reactance, and resistance.
- ET-16 Disadvantages of using a surface probe coil for the eddy current inspection of small-diameter tubing include:
- inability to detect small discontinuities.
 - slow inherent speed.
 - inherent mechanical problems.
 - all of the above.
 - both b and c.

- ET-17 The term "fill factors" applies to:
- a surface coil.
 - coaxial cable.
 - an encircling coil.
 - the ability to null an eddy current instrument.
- ET-18 Which of the following materials would be more likely used as a mounting material for a probe coil?
- Aluminum.
 - Plastic.
 - Copper.
 - Nonferromagnetic steel.
- ET-19 Which of the following is not a commonly used eddy current testing read-out mechanism?
- Signal generator.
 - Meter.
 - Cathode ray tube.
 - Strip-chart recorder.
- ET-20 Reference standards used for eddy current testing:
- must contain artificial discontinuities such as notches and drilled holes.
 - must contain natural discontinuities such as cracks and inclusions.
 - must be free of measurable discontinuities but may contain artificial or natural discontinuities or may be free of discontinuities, depending on the test system and the type of test being conducted.
 - are not typically described in any of the above.
- ET-21 Which of the following conditions is not important when selecting specimens to be used as reference standards?
- The specimen should be of the same size and shape as the piece to be tested.
 - The specimen should be of the same materials and have the same heat treatment as the piece to be tested.
 - The surface finish of the specimen should be the same as the piece to be tested.
 - If the material is aluminum, the surface should be anodized.
 - All of the above conditions are important.
- ET-22 Which of the following conditions would be the most difficult to detect when eddy current testing a rod using an encircling coil?
- A short surface crack that has a depth of 10% of the rod diameter.
 - A small inclusion in the center of the rod.
 - A 5% change in diameter.
 - A 10% change in conductivity.
- ET-23 The thickness of nonconductive coatings on a conductive base can be most simply measured by:
- observing the lift-off effect caused by the coating.
 - testing both sides of the specimen.
 - varying the test frequency over a given range during the test.
 - using a specially shaped encircling coil.
- ET-24 Some of the products commonly tested using encircling coils are:
- rods, tubes, and wire.
 - interior of hollow tubes.
 - sheets and metal foil.
 - all of the above.

ET-25 It is often possible to sort various alloys of a nonmagnetic metal by means of an eddy current test when:

- a. there is a unique range of permeability values for each alloy.
- b. there is a unique range of conductivity values for each alloy.
- c. the direction of induced eddy currents varies for each alloy.
- d. the magnetic domains for each alloy are different.
- e. the alloy is slightly magnetic, but not if totally nonmagnetic.

ET-26 When eddy current testing tubing with a system that includes a frequency discriminating circuit, which of the following variables would be classified as a high frequency variable?

- a. Small discontinuities.
- b. Conductivity changes.
- c. Diameter changes.
- d. Wall thickness variations.

ET-27 Which of the following is not a candidate for testing by the eddy current method?

- a. A 102 mm (4 in.) thick plate to be tested for discontinuities throughout the plate.
- b. Tubing to be tested for surface cracks.
- c. Rod to be tested for laps and seams.
- d. Tubing to be tested for variation in outside diameter.
- e. Both a and d.

Infrared/Thermal Testing (IR)

Topical Outline

1.0 Fundamentals

- 1.1 Principles and theory of infrared/thermal testing
- 1.2 Temperature measurement principles
- 1.3 Proper selection of infrared/thermal technique

2.0 Equipment/materials

- 2.1 Temperature measurement equipment
- 2.2 Heat flux indicators
- 2.3 Noncontact devices

3.0 Applications

- 3.1 Contact temperature indicators
- 3.2 Noncontact pyrometers
- 3.3 Line scanners
- 3.4 Thermal imaging
- 3.5 Heat flux indicators
- 3.6 Exothermic or endothermic investigations
- 3.7 Friction investigations
- 3.8 Fluid flow investigations
- 3.9 Thermal resistance investigations
- 3.10 Thermal capacitance investigations

4.0 Interpretation and evaluation

Reference

Wolfe, William L. and George J. Ziessis, eds. *The Infrared Handbook*. The Environmental Research Institute of Michigan (prepared for the Department of Navy). 1985.

Review Questions

IR-1 Thermal resistance is:

- a. analogous to electrical current.
- b. a material's impedance to heat flow.
- c. proportional to the fourth power of emissivity.
- d. proportional to the rate of heat flow.

IR-2 Conductive heat transfer cannot take place:

- a. across a vacuum.
- b. within organic materials such as wood.
- c. between two solid materials in contact.
- d. between dissimilar metals.

IR-3 The radiation of infrared/thermal energy from a target surface:

- a. occurs most efficiently in a vacuum.
- b. is proportional to the fourth power of the absolute surface temperature.
- c. is directly proportional to surface emissivity.
- d. does all of the above.

- IR-4 Thermal radiation reaching the surface of an object can be:
- absorbed only in the presence of atmosphere.
 - reflected and absorbed only in a vacuum.
 - absorbed, reflected, and transmitted.
 - transmitted only if the surface is organic.
- IR-5 The following spectral band is included in the infrared spectrum:
- 0.1-5.5 μm .
 - 0.3-10.6 μm .
 - 0.4-20.0 μm .
 - 0.75-100 μm .
- IR-6 As a surface cools, the peak of its radiated infrared energy:
- shifts to longer wavelengths.
 - shifts to shorter wavelengths.
 - remains constant if emissivity remains constant.
 - remains constant even if emissivity varies.
- IR-7 A graybody surface with an emissivity of 0.04 would be:
- transparent to infrared radiation.
 - a fairly good emitter.
 - almost a perfect reflector.
 - almost a perfect emitter.
- IR-8 If a surface has an emissivity of 0.35 and a reflectivity of 0.45, its transmissivity would be:
- impossible to determine without additional information.
 - 0.80.
 - 0.10.
 - 0.20.
- IR-9 The spectral band in which glass transmits infrared radiation most efficiently is the:
- 3.0-6.0 μm region.
 - 2.0-3.0 μm region.
 - 6.0-9.0 μm region.
 - 9.0-11.0 μm region.
- IR-10 Infrared thermal detectors:
- have a broad, flat spectral response.
 - have much faster response times than photon detectors.
 - usually require cooling to operate properly.
 - have much greater sensitivity than photon detectors.
- IR-11 A diffuse reflecting surface is:
- a polished surface that reflects incoming energy at a complementary angle.
 - a surface that scatters reflected energy in many directions.
 - also called a specular reflecting surface.
 - usually transparent to infrared radiation.
- IR-12 The thermal resolution of an instrument is the same as:
- the temperature accuracy.
 - minimum resolvable temperature difference.
 - temperature repeatability.
 - the minimum spot size.
- IR-13 The instantaneous spot size of an instrument is related to the:
- instantaneous field of view and the working distance.
 - thermal resolution.
 - spectral band width and the working distance.
 - speed of response and the working distance.

- IR-14 The thermal resolution of an instrument tends to:
- improve as the target temperature increases.
 - degrade as the target temperature increases.
 - remain constant regardless of the target temperature.
 - improve with increasing working distance.
- IR-15 The 3-5 μm spectral region is well suited for operation of instruments:
- measuring sub-zero temperature targets.
 - measuring targets at extremely long working distances.
 - measuring targets warmer than 200 $^{\circ}\text{C}$ (392 $^{\circ}\text{F}$).
 - operating at elevated ambient temperatures.
- IR-16 Adding an infrared spectral filter to an instrument limits the spectral band:
- to only wavelengths longer than a specified wavelength.
 - to only wavelengths shorter than a specified wavelength.
 - to only wavelengths between two specified wavelengths.
 - all of the above are true.
- IR-17 A line scanner can be best used to produce a thermogram of a sheet process when:
- the sheet process is moving at a uniform rate.
 - emissivity is known.
 - the process material is a non-graybody.
 - the sheet process is hotter than 200 $^{\circ}\text{C}$ (392 $^{\circ}\text{F}$).
- IR-18 Most infrared focal plane array imagers:
- use more costly optics than scanning radiometers.
 - offer better spatial resolution than scanning radiometers.
 - offer better thermal resolution than scanning radiometers.
 - offer more diagnostics features than scanning radiometers.
- IR-19 When measuring the temperature of a non-gray target:
- the viewing angle is not critical.
 - always assume an emissivity of 1.0.
 - reflections off the near surface may be ignored.
 - errors may be caused by hot sources in the background.
- IR-20 Unfinished metal surfaces usually have:
- high and uniform emissivities.
 - low and uniform emissivities.
 - non-graybody characteristics.
 - low specular reflectivity.
- IR-21 Thermal diffusivity is:
- high for metals and low for porous materials.
 - the same for all metals.
 - low for metals and high for porous materials.
 - the same for all porous materials.
- IR-22 The 3-dimensional resistance to temperature change within a material is called:
- diffuse reflectivity.
 - thermal effusivity.
 - thermal conductance.
 - spectral transmittance.

Leak Testing (LT)

Topical Outline

- 1.0 Fundamentals
 - 1.1 Bubble detection
 - 1.2 Pressure change
 - 1.3 Halogen diode detector
 - 1.4 Mass spectrometer
- 2.0 Leak Testing
 - 2.1 Systems factors
 - a. Relative sensitivity
 - b. Evacuated systems
 - c. Pressurized systems: ambient fluids, tracer fluids
 - d. Locating leaks
 - e. Calibration
 - 2.2 Test result interpretation
 - 2.3 Essentials of safety
 - 2.4 Test equipment
 - 2.5 Applications
 - a. Piping and pressure vessels
 - b. Evacuated systems
 - c. Low pressure fluid containment vessels, pipes, and tubing
 - d. Hermetic seals
 - e. Electrical and electronic components

References

McMaster, R.C. ed. Volume 1, *Leak Testing*.
Columbus, OH: The American Society for
Nondestructive Testing, Inc. 1982.

Review Questions

- LT-1 Which of the following systems or components are candidates for leak testing?
- a. Piping and pressure vessels.
 - b. Refrigeration piping.
 - c. Vacuum chambers.
 - d. All of the above.
 - e. Both a and b.
- LT-2 A helium mass spectrometer is used in which of the following NDT method(s)?
- a. X-ray spectroscopy.
 - b. Optical holography.
 - c. Acoustic holography.
 - d. Leak testing.
 - e. Both b and c.
- LT-3 Which of the following is a technique of leak testing?
- a. Bubble detection.
 - b. Measurement of pressure changes.
 - c. Halogen "sniffing."
 - d. All of the above.
- LT-4 Potentially, the most sensitive leak testing technique is the:
- a. bubble test.
 - b. pressure change test.
 - c. mass spectrometer test.
 - d. liquid penetrant test.
- LT-5 Establishing differential pressure between the test object and environment is an essential element in which of the following NDT methods?
- a. X-ray diffraction.
 - b. Neutron radiography.
 - c. Leak testing.
 - d. Gamma radiography.
 - e. Eddy current testing.
- LT-6 Which of the following best describes the type of leak test used when the interior of the test object is evacuated and a tracer gas is applied to the exterior, while the leak detector is connected to the evacuating system?
- a. Static leak test.
 - b. Helium leak test.
 - c. Dynamic leak test.
 - d. Halogen leak test.
 - e. Sniffer leak test.
- LT-7 Assuming no significant leakage, if the temperature increased during a pressure drop leak test, the pressure in the system under test would:
- a. increase.
 - b. remain the same.
 - c. decrease.
 - d. first increase, then decrease to its former level.

- LT-8 If the sensitivity of the halogen leak detector is maintained constant throughout a test, which of the following is true upon completion of the test?
- No leaks of a certain size or larger have gone undetected.
 - The total leak rate of the test object is less than a certain amount.
 - The instrument and test procedure were capable of detecting leakage of a certain size during the test.
 - All of the above.
- LT-9 All leak detection methods are dependent upon:
- barometric pressure.
 - gas or fluid flow.
 - mass spectrometers analysis.
 - mean free paths of helium flow.
- LT-10 In an evacuated system, sensitivity of a pressure change leak test is dependent not only on the pressure change observed, but also on the degree of outgassing. Outgassing is best defined as:
- the viscosity of the pressurizing gas.
 - being directly proportional to the temperature of the gas.
 - the release of gases which were absorbed into the walls of the test container.
 - the drop in test pressure due to leakage from the vacuum manifold.
 - a phenomenon whereby gases in an evacuated system eventually leak to the outside of the system if vacuum is maintained.

Liquid Penetrant Testing (PT)

Topical Outline

- Fundamentals
 - Interaction of penetrants and discontinuity openings
 - Fluorescence and contrast
- Liquid Penetrant Testing
 - Penetrant processes
 - Test equipment and systems factors
 - Test result interpretation; discontinuity indications
 - Applications
 - Castings
 - Welds
 - Wrought metals
 - Machined parts
 - Leaks
 - Field inspections

Reference

McMaster, R.C., ed. Volume 2, *Liquid Penetrant Tests*. Columbus, OH: The American Society for Nondestructive Testing, Inc. 1982.

Review Questions

- PT-1 The tendency of a liquid penetrant to enter a discontinuity is primarily related to:
- the viscosity of the penetrant.
 - capillary forces.
 - the chemical inertness of the penetrant.
 - the specific gravity of the penetrant.
 - all of the above.
- PT-2 Liquid penetrant testing is a nondestructive test that can be used for:
- locating and evaluating all types of discontinuities in a test specimen.
 - locating and determining the length, width, and depth of discontinuities in a test specimen.
 - determining the tensile strength of a test specimen.
 - locating discontinuities open to the surface.
 - a, b, and d.

- PT-3 Which of the following is not a characteristic that applies to liquid penetrant testing?
- This method can accurately measure the depth of a crack or discontinuity.
 - This method can be used for on-site testing of large parts.
 - This method can be used to find shallow surface discontinuities.
 - This method can be made more or less sensitive by using different penetrant materials.
- PT-4 The property of a dye used in penetrant materials to emit light of a range of wavelengths different from the wavelength of light that excites the emission is called:
- emissivity.
 - irradiation.
 - black light.
 - spectrum blocking.
 - fluorescence.
- PT-5 When using a fluorescent, post-emulsifier penetrant, the length of time the emulsifier is allowed to remain on the part is critical for detecting shallow discontinuities. The optimum length of time should be:
- 10 seconds.
 - 5 seconds.
 - 2-3 minutes.
 - determined by experimentation.
- PT-6 A red penetrant indication against white background is most likely to be seen when:
- dry developers are used.
 - visible dye penetrants are used.
 - fluorescent post-emulsified penetrants are used.
 - wet developers are used.
 - ultraviolet light is used with visible dye penetrants.
- PT-7 The most widely accepted method for removing excessive water-washable penetrant from the surface of a test specimen is by:
- using a wet rag.
 - using a water spray rinse.
 - washing the part directly under water running from a tap.
 - immersing the part in water.
- PT-8 Which of the following penetrant systems is generally considered the least sensitive?
- Water-washable; visible dye.
 - Solvent-removable; visible dye.
 - Water-washable; fluorescent dye.
 - Post-emulsified; visible dye.
- PT-9 When performing a liquid penetrant test using solvent-removable visible dye penetrant, there are several ways to remove excess penetrant from the surface of the part. Which of the methods listed below is generally regarded as most suitable for giving accurate test results?
- Squirting solvent over the surface with no more than 10 psi pressure.
 - Wiping with a solvent-soaked cloth, then wiping with a dry cloth.
 - Wiping with a solvent-dampened cloth, then wiping with dry cloths.
 - Wiping with dry wipes, then wiping with a solvent-dampened cloth, and finally wiping with dry cloth.
- PT-10 A problem with retesting a specimen that has been previously tested using liquid penetrant is that:
- the penetrant may form beads on the surface.
 - the penetrant residue left in discontinuities may not readily dissolve and the retest may be misleading.
 - the penetrant will lose a great deal of its color brilliance.
 - none of the above are correct statements.

- PT-11 A commonly used method of checking the overall performance of a penetrant material system is to:
- determine the viscosity of the penetrant.
 - measure the wettability of the penetrant.
 - compare two sections of artificially cracked specimens.
 - do all of the above.
- PT-12 The function of emulsifier in the post-emulsified penetrant process is to:
- more rapidly drive the penetrant into deep, tight cracks.
 - react with the surface penetrant to make the penetrant water-washable.
 - add fluorescent dye or pigment to the penetrant.
 - provide a coating to which dry powder developer can adhere.
 - emulsify surface oils and greases to facilitate their removal.
- PT-13 Which of the following statements does not apply to developers used during penetrant testing?
- Developers are normally highly fluorescent.
 - Some developers furnish a contrasting background during inspection.
 - Developers absorb or blot the penetrant that remains in discontinuities after the excess penetrant has been removed.
 - All of the above are true statements.
- PT-14 The penetrant indication for a cold shut on the surface of a casting will normally be:
- a dotted line.
 - a cluster of small indications.
 - a smooth continuous line.
 - a large bulbous indication.
 - undetectable since cold shuts are closed over on the surface.
- PT-15 A crack-type discontinuity will generally appear as:
- a rounded indication.
 - a continuous line, either straight or jagged.
 - a broad, fuzzy indication.
 - random round or elongated holes.
- PT-16 In a penetrant test, scattered round indications on the surface of a part could be indicative of:
- fatigue cracks.
 - porosity.
 - weld laps.
 - hot tears.
 - grinding cracks.
- PT-17 Which of the following are typical nonrelevant indications found in penetrant testing?
- Indications due to part geometry or part design configurations.
 - Nonmagnetic indications.
 - Multiple indications.
 - Nonlinear indications.
 - Indications on low-stressed areas of the part.
- PT-18 Which of the statements below best states the results of sandblasting for cleaning surfaces to be penetrant tested?
- Discontinuities may be closed.
 - Oil contaminants might be sealed in the discontinuities.
 - The sand used in the sandblasting operation may be forced into the discontinuity.
 - The sandblasting operation may introduce discontinuities into the part.
 - None of the above.
- PT-19 The penetrant indication of a forging lap will normally be:
- a round or nearly round indication.
 - a cluster of indications.
 - a thin continuous line.
 - a dotted line.

- PT-20 Aluminum alloy test specimens that have been tested by the liquid penetrant method should be thoroughly cleaned after testing because:
- acid in the penetrant may cause severe corrosion.
 - the alkalines in wet developers and most emulsifiers could cause surface pitting, particularly in moist atmospheres.
 - the oily residue from the test will severely inhibit the application of paint on aluminum alloys.
 - a chemical reaction between the penetrant and aluminum could cause a fire.
- PT-21 Penetrants may be used for leak detection:
- if surfaces are clean.
 - if both sides are accessible.
 - in dilute form during hydro-test.
 - effectively by using fluorescent tracers.
 - in all of the above.
- PT-22 Which of the following is a discontinuity that might be found in rolled bar stock?
- Blow holes.
 - Shrinkage laps.
 - Cracks or seams.
 - Insufficient penetration.
- PT-23 Anodized surfaces are usually considered poor candidates for high sensitivity liquid penetrant examination because the anodizing process produces a conversion layer that:
- is extremely smooth and slick.
 - has a multitude of extremely small pores.
 - may have alkaline residue which "quenches" the penetrant.
 - cannot be cleaned by ordinary processes.
 - flakes off on contact with penetrant materials.
- PT-24 Which of the following penetrant methods does not normally require a source of electricity to properly conduct a test?
- Water-washable fluorescent penetrant method.
 - Post-emulsified fluorescent penetrant method.
 - Visible dye penetrant method.
 - None of the above require a source of electricity.
- PT-25 Which of the following statements is true concerning penetrant testing of welds with rough surfaces?
- The post-emulsified process offers advantages over the water-washable process.
 - Weld surfaces must be ground flush in order to expose all subsurface discontinuities.
 - If the solvent-removal process is used, the best developer would be an aqueous suspension.
 - Welds with rough surfaces cannot be successfully tested by any penetrant method.
 - None of the above statements is true.

Magnetic Particle Testing (MT)

Topical Outline

- Fundamentals
 - Magnetic field principles
 - Magnetization by means of electric current
 - Demagnetization
- Magnetic particle inspection
 - Basic types of equipment and inspection materials
 - Test result interpretation; discontinuity indications
 - Applications
 - Welds
 - Castings
 - Wrought metals
 - Machined parts
 - Field inspections

Reference

Schmidt, J. Thomas and Kermit Skeie, technical eds., Paul McIntire, ed. Volume 6, *Magnetic Particle Testing*. Columbus, OH: The American Society for Nondestructive Testing, Inc. 1989.

Review Questions

- MT-1 Which of the following materials cannot be tested by magnetic particle techniques?
- High alloy steels.
 - Tool steels.
 - Copper alloys.
 - Ferritic stainless steels.
 - Both c and d.
- MT-2 Materials that are strongly attracted to a magnet are called:
- magnetized.
 - nonmagnetic.
 - ferromagnetic.
 - magnetic.
- MT-3 Magnetic lines of force (magnetic fields) are oriented in what direction in relation to the direction of the magnetizing current?
- Parallel.
 - At right angles.
 - At a 45° angle.
 - One angular orientation is random.
- MT-4 Magnetizing flux is a term that relates to:
- describing the direction of current flow in an electromagnet.
 - the manner by which magnetism flows through space.
 - the number of lines of force associated with a magnetic field.
 - permanent magnets only.
- MT-5 Subjecting a part to a magnetic field that is constantly reversing in polarity and gradually diminishing in strength accomplishes which of the following?
- The part is magnetized.
 - The part is demagnetized.
 - The remanence of the magnetic field is increased.
 - Deep-lying discontinuities are more easily located.
- MT-6 Circular magnetization is useful in the detection of:
- circumferential cracks.
 - longitudinal cracks.
 - cracks in cylindrical parts at right angles to the long axis of the part.
 - Both a and c.
- MT-7 In which magnetizing method is the current passed directly through the part, thereby setting up a magnetic field at right angles to the current flow?
- Longitudinal magnetization.
 - Coil magnetization.
 - Central conductor magnetization.
 - All of the above.
 - None of the above.
- MT-8 Which of the following is a major disadvantage of using the prod method?
- The magnetic field may be applied in the wrong direction.
 - The inspection surface may be arc burned.
 - Magnetic saturation may occur.
 - The operator's eyes may be burned by arc strikes.
- MT-9 Inspecting a part by applying the magnetic particle suspension while the current is flowing is called the:
- continuous method.
 - dry method.
 - residual method.
 - demagnetization method.

- MT-10 How is the inside diameter of a cylinder best magnetized?
- By a head shot.
 - By using prods at either end.
 - With a central conductor placed between contact heads.
 - With the cylinder placed crosswise in a solenoid.
- MT-11 The amount of amperage used for magnetic particle inspection using the prod method is based on the:
- thickness of the part.
 - distance between the prods.
 - diameter of the prods.
 - total length of the part.
 - all of the above.
- MT-12 Demagnetization of a part is usually not necessary if the part is:
- small.
 - inspected with the continuous method.
 - to be hardened by heat treatment after inspection.
 - high carbon steel to be welded after inspection.
- MT-13 Which of the following is an advantage of the dry method over the wet method?
- It is more sensitive for detecting fine surface cracks.
 - It is more capable of providing full surface coverage on irregularly shaped parts.
 - It is easier to use for field inspection with portable equipment.
 - It is faster when testing a number of small parts.
 - The equipment cost is lower.
- MT-14 Fluorescent magnetic particles are used in preference to visible magnetic particles:
- when parts are big and bulky.
 - to take advantage of the fluorescent lights that are normally used in plants.
 - if parts are for railroad applications.
 - to increase the speed and reliability of detecting very small discontinuities.
- MT-15 The most versatile type of magnetic particle equipment is:
- portable equipment.
 - the stationary horizontal machine.
 - the mobile power unit.
 - the automatic machine.
 - a field kit.
- MT-16 Magnetic particle inspection methods are recognized as superior to liquid penetrant techniques when the:
- surfaces of the test object are corroded.
 - surface is anodized.
 - parts are painted.
 - part is made from austenitic steel.
- MT-17 When using direct current, an indication is detected. What is the next logical step to determine if the indication results from a surface or subsurface condition?
- Reinspect using the surge method.
 - Demagnetize and apply powder.
 - Reinspect at higher amperage.
 - Reinspect using alternating current.
- MT-18 A requirement to use magnetic particle testing on a part should also include:
- a fabrication and service manual.
 - a statement on the drawing that requires a magnetic particle test.
 - the procedure to be used and acceptance criteria.
 - the method of test and service conditions.

MT-19 The statement that magnetic particle testing can be applied to plated and painted parts:

- a. is true regardless of the thickness of the coating.
- b. may be true if flux densities are increased to compensate for the coating thickness.
- c. is true only for circular magnetism.
- d. is not true under any circumstances.

MT-20 The best type of magnetizing current for inspection of fatigue cracks is:

- a. direct current.
- b. alternating current.
- c. half-wave direct current.
- d. full-wave rectified direct current.
- e. any of the above if the current is correct.

MT-21 A star-shaped indication was seen on the cover pass of a weld. What type of discontinuity was indicated?

- a. A cooling crack.
- b. A crater crack.
- c. A slag inclusion.
- d. A lack of fusion.
- e. An arc burn.

MT-22 For maximum sensitivity in magnetic particle inspection of rough welds:

- a. the weld should be wire brushed to remove slag and scale.
- b. standard test weldments should be used for comparison.
- c. the weld bead should be coated with lacquer.
- d. the weld bead should be ground flush with the plate surfaces.

Neutron Radiographic Testing (NR)

Topical Outline

- 1.0 Fundamentals
 - 1.1 Sources
 - a. X-ray
 - b. Isotopic
 - c. Neutron
 - 1.2 Detectors
 - a. Imaging
 - b. Non-imaging
 - 1.3 Nature of penetrating radiation and interactions with matter
 - 1.4 Essentials of safety
- 2.0 Radiographic testing
 - 2.1 Basic imaging considerations
 - 2.2 Test result interpretation; discontinuity indications
 - 2.3 Systems factors (source/test object/detector interactions)
 - 2.4 Applications
 - a. Explosives and pyrotechnic devices
 - b. Assembled components
 - c. Bonded components
 - d. Corrosion detection
 - e. Nonmetallic materials

References

Berger, Harold, ed., *Practical Applications of Neutron Radiography and Gaging*, American Society for Testing and Materials, Philadelphia, PA, 1976 (STP-586); pp. 5-73, 87-113.

Bryant, Lawrence E., technical ed., Paul McIntire, ed. Volume 3, *Radiography and Radiation Testing*. Columbus, OH: The American Society for Nondestructive Testing, Inc. 1985.

Review Questions

- NR-1 The highest intensity sources of thermal neutrons are:
- a. Cf-252 isotopes.
 - b. accelerators.
 - c. nuclear reactors.
 - d. none of the above.

- NR-2 Neutrons for fast-neutron radiography are obtainable from:
- accelerators.
 - radioactive sources.
 - reactors.
 - all of the above.
 - none of the above.
- NR-3 A radioactive source used for neutron radiography is:
- Pu-239.
 - Co-60.
 - Cs-137.
 - Cf-252.
 - all of the above.
- NR-4 The energy of the neutron is expressed in which of the following units of measurement?
- Curies.
 - Roentgens.
 - Half-life.
 - Electron-volts.
 - REMs.
- NR-5 A normally desirable feature of a thermal neutron beam for neutron radiography is:
- low gamma radiation intensity.
 - relatively low fast-neutron intensity.
 - low angular divergence.
 - both a and b.
- NR-6 Material that slows down neutrons is called:
- a moderator.
 - an accumulator.
 - a limiter.
 - a reducer.
 - a collimator.
- NR-7 The primary radiation mechanism for darkening X-ray film when the direct neutron radiography process is used with gadolinium screens is:
- alpha particles.
 - electrons.
 - gamma rays.
 - light emission.
- NR-8 Neutron radiography using the transfer method requires that the imaging screen:
- be placed behind the film.
 - be placed in front of the film.
 - be very thin.
 - become radioactive.
 - emit light.
- NR-9 Which of the following neutron radiography converter foils cannot be used for transfer or indirect radiography?
- Dysprosium.
 - Indium.
 - Gadolinium.
 - Gold.
- NR-10 The most suitable films for producing neutron radiographs are:
- red sensitive films.
 - instant-type films.
 - industrial X-ray films.
 - medical X-ray films.
 - emulsions that contain no silver halides.
- NR-11 Materials that are exposed to thermal neutron beams:
- must not be handled for at least 3 minutes after exposure has ceased.
 - must be stored in a lead-lined room.
 - may be radioactive after exposure to neutrons has ceased.
 - should be monitored by means of a neutron counter.
 - present no particular problems since they cannot be radioactive.

NR-12 Lead is:

- a. a good neutron shield.
- b. corroded by neutron exposures.
- c. a relatively poor neutron absorber.
- d. an efficient conversion screen.

NR-13 If 2 mm (0.08 in.) of plastic attenuates a thermal neutron beam by a factor of 2, then 20 mm (0.8 in.) will attenuate it by approximately a factor of:

- a. 10.
- b. 20.
- c. 100.
- d. 200.
- e. 1,000.

NR-14 Materials in common usage for moderation of fast-neutron sources include:

- a. aluminum, magnesium, and tin.
- b. water, plastic, paraffin, and graphite.
- c. neon, argon, and xenon.
- d. tungsten, cesium, antimony, and columbium.

NR-15 The main reason for using neutron radiography in place of X-radiography is:

- a. a lower cost.
- b. higher resolution.
- c. the ability to image objects and materials not possible with X-rays.
- d. a simpler radiographic procedure required than X-radiography.

NR-16 A photographic record produced by the passage of neutrons through a specimen onto a film is called:

- a. a fluoroscopic image.
- b. a radiograph.
- c. an isotopic reproduction.
- d. a track-etch photograph.

NR-17 Many of the absorption differences between neutrons and X-rays indicate that the two techniques:

- a. cause radiation problems.
- b. complement each other.
- c. can be used interchangeably.
- d. can both be used to image hydrogenous materials equally well.
- e. are in no manner related.

NR-18 The penetrating ability of a thermal neutron beam is governed by:

- a. attenuating characteristics of the material being penetrated.
- b. exposure time.
- c. source-to-film distance.
- d. all of the above.

NR-19 The transfer exposure method is used because:

- a. it is not influenced by gamma radiation in the primary beam.
- b. it produces greater radiographic sensitivity than the direct exposure using gadolinium.
- c. it is faster than the direct exposure method.
- d. the screens used in this method emit only internal conversion electrons of about 70 keV.

NR-20 Higher resolution can be achieved in direct neutron radiography by:

- a. placing a lead intensifying screen between a gadolinium screen and film.
- b. increasing the L/D ratio of the collimation system.
- c. increasing the exposure time.
- d. increasing the distance between the object and the film cassette.

NR-21 The primary advantage of using a Cf-252 source for neutron radiography is its:

- portability.
- low cost per unit neutron flux compared to other neutron radiographic sources.
- high resolution.
- long useful life.

NR-22 Quality of the results from a neutron radiographic exposure is best determined by:

- reference standards.
- image quality indicators.
- neutron flux measurement.
- densitometer readings.

NR-23 The radiographic image of flaws in the imaging screens can be separated from actual flaws in a part being radiographed by:

- producing a photographic copy of the original neutron radiograph using X-ray duplicating film.
- comparing a neutron radiograph of the parts to a blank neutron radiograph of the same imaging screen with no parts in place.
- increasing the exposure time of the radiograph.
- decreasing the temperature of the developer solution.

NR-24 For inspection of radioactive objects or those that emit gamma radiation when bombarded with neutrons, a preferable detection technique is the:

- direct exposure technique.
- transfer technique.
- isotopic reproduction technique.
- electrostatic-belt generator technique.
- lead screen technique.

NR-25 Neutron radiography is an excellent tool for determining:

- the coating thickness of aluminum oxide on anodized aluminum.
- the size of voids in thick steel castings.
- the integrity of thin plastic material within a steel housing.
- none of the above.

NR-26 Neutron radiography extends radiographic capability for detecting cracks in small cylinders of:

- aluminum.
- iron.
- magnesium.
- plutonium.
- bronze.

NR-27 Which of the following is not a preferred application of neutron radiography?

- Detecting the presence or absence of explosive material contained within a metal device.
- Detecting the presence of water in the cells of stainless steel honeycomb.
- Detecting the proper alignment of a rubber seal in a small steel valve assembly.
- Detecting the presence of a lead rupture diaphragm in a small aluminum safety valve assembly.

Radiographic Testing (RT)

Topical Outline

1.0 Fundamentals

1.1 Sources

- X-ray
- Isotopic
- Neutron

1.2 Detectors

- Imaging
- Nonimaging

1.3 Nature of penetrating radiation and interactions with matter

1.4 Essentials of safety

2.0 Radiographic Testing

- 2.1 Basic imaging considerations
- 2.2 Test result interpretation; discontinuity indications
- 2.3 Systems factors (source/test object/detector interactions)
- 2.4 Applications
 - a. Castings
 - b. Welds
 - c. Assemblies
 - d. Electronic components
 - e. Field inspections

Reference

Bryant, Lawrence E., technical ed., Paul McIntire, ed. Volume 3, *Radiography and Radiation Testing*. Columbus, OH: The American Society for Nondestructive Testing, Inc. 1985.

Review Questions

- RT-1 The penetrating ability of an X-ray beam is governed by:
- a. kilovoltage or wavelength.
 - b. time.
 - c. milliamperage.
 - d. source-to-film distance.
- RT-2 Two X-ray machines operating at the same nominal kilovoltage and milliamperage settings:
- a. will produce the same intensities and energies of radiation.
 - b. will produce the same intensities but may produce different energies of radiation.
 - c. will produce the same energies but may produce different intensities of radiation.
 - d. may give not only different intensities but also different energies of radiation.
- RT-3 Which of the following X-ray generators would produce the narrowest cone of X-radiation?
- a. 10 MeV.
 - b. 15 MeV.
 - c. 25 MeV.
 - d. 1 MeV.
 - e. Co-60.
- RT-4 Short wavelength electromagnetic radiation produced during the disintegration of nuclei of radioactive substances is called:
- a. X-radiation.
 - b. gamma radiation.
 - c. scatter radiation.
 - d. backscatter radiation.
 - e. beta radiation.
- RT-5 Almost all gamma radiography is performed with:
- a. natural isotopes.
 - b. artificially produced isotopes.
 - c. Radium.
 - d. Tm-170.
 - e. Co-60.
- RT-6 The energy of gamma rays is expressed by which of the following units of measurement?
- a. Curie.
 - b. Roentgen.
 - c. half-life.
 - d. Kiloelectron volts (keV) or Millions of electron volts (MeV).
 - e. None of the above.
- RT-7 Of the following, the source providing the most penetrating radiation is:
- a. Co-60.
 - b. 220 kVp X-ray tube.
 - c. 15 MeV betatron.
 - d. electrons from Ir-192.

- RT-8 Common sources of neutrons for neutron radiography are:
- electron linear accelerators.
 - isotopes of Cobalt (Co-60 is one).
 - nuclear reactors.
 - betatrons.
 - radioactive isotopes of iodine.
- RT-9 The difference between the densities of two areas of a radiograph is called:
- radiographic contrast.
 - subject contrast.
 - film contrast.
 - definition.
 - opacity.
- RT-10 The fact that gases, when bombarded by radiation, ionize and become electrical conductors makes them useful in:
- X-ray transformers.
 - X-ray tubes.
 - masks.
 - radiation detection equipment.
 - fluoroscopes.
- RT-11 The reason exposure time must be increased by a factor of four when the source-to-film distance is doubled is that the:
- intensity of radiation decreases at an exponential rate when the source-to-film distance is increased.
 - energy of radiation is inversely proportional to the square root of the distance from the source to the film.
 - intensity of radiation is inversely proportional to the square of the distance from the source to the film.
 - scattered radiation effect is greater as the source-to-film distance increases.
- RT-12 The most important factor in X-ray absorption of a specimen is:
- the thickness of the specimen.
 - the density of the specimen.
 - the atomic number of the material.
 - Young's Modulus of the material.
 - the volume of the material.
- RT-13 Which of the following is the probable early effect of a 25 REM radiation dose to the whole body?
- No physical effect.
 - Blood changes, no serious injury.
 - Injury, possible disability.
 - Fatal to 50 percent of those receiving that dose.
- RT-14 Exposure to small doses of X-rays or gamma rays:
- have a cumulative effect that must be considered when monitoring for maximum permissible dose.
 - are beneficial because they serve to build an immunity in humans to radiation poisoning.
 - will have no effect on human beings.
 - will have only a short-term effect on human tissues.
- RT-15 Which of the following technique variables is most commonly used to adjust subject contrast?
- Source-to-film distance.
 - Milliamperage.
 - Kilovoltage.
 - Focal spot size.
 - All of the above.
- RT-16 A basic difference between a radiograph and a fluoroscopic image is that:
- the fluoroscopic image is more sensitive.
 - the fluoroscopic image is positive whereas the radiographic image is negative.
 - the fluoroscopic image is brighter.
 - there is no basic difference between the two.

- RT-17 Thin sheets of lead foil in intimate contact with X-ray film during exposure increase film density because they:
- fluoresce and emit visible light, which helps expose the film.
 - absorb the scattered radiation.
 - prevent backscattered radiation from fogging the film.
 - emit electrons when exposure to X- and gamma radiation, which helps to darken the film.
 - absorb low energy components from the primary beam.
- RT-18 When viewing a radiograph, an image of the back of the cassette superimposed on the image of the specimen is noted. This is most likely due to:
- undercut.
 - overexposure.
 - X-ray intensity being too high.
 - backscattered radiation.
- RT-19 A penetrometer is used to measure the:
- size of discontinuities in a part.
 - density of the film.
 - amount of film contrast.
 - quality of the radiographic technique.
 - amount of radiation that penetrates the test object.
- RT-20 In film radiography, penetrameters are usually placed:
- between the intensifying screen and the film.
 - on the source side of the test object.
 - on the film side of the test object.
 - between the operator and the radiation source.
 - on the back side of the film.
- RT-21 At voltages above 400 kV, the use of lead to provide protection may present serious structural problems. If this should be a serious problem, which of the following materials would most likely be used as a substitute?
- Aluminum.
 - Concrete.
 - Steel.
 - Boron.
 - Polyethylene.
- RT-22 A distinctive characteristic of high voltage radiography is that:
- it results in comparatively high subject contrast.
 - it results in comparatively high radiographic contrast.
 - it is applicable to comparatively thick or highly absorbing specimens.
 - all of the above are distinctive characteristics of high voltage radiography.
- RT-23 Given the radiographic equivalency factors of 1.4 for Inconel and 1.0 for 304 stainless steel, what is the approximate equivalent thickness of Inconel to produce the same exposure as a 0.15 in. thickness of 304 stainless steel?
- 3 mm (0.11 in.)
 - 9 mm (0.35 in.)
 - 18 mm (0.7 in.)
 - 36 mm (1.4 in.)
- RT-24 Upon completing an X-ray exposure and turning the equipment off, personnel:
- should wait for a few minutes before entering the exposure area.
 - should wear a lead-lined apron before entering the exposure area.
 - may enter the exposure area without fear of radiation exposure.
 - should take a reading with a Geiger counter before entering the exposure area.

- RT-25 The fact that each solid crystalline substance produces its own characteristic X-ray pattern is the basis for:
- xeroradiography.
 - fluoroscopic testing.
 - polymorphic testing.
 - X-ray diffraction testing.
 - neutron radiography.
- RT-26 When inspecting a light metal casting by fluoroscopy, which of the following discontinuities would most likely be detected?
- Copper shrinkage.
 - Microshrinkage.
 - Shrinkage.
 - Fine cracks.
- RT-27 For testing a 25 mm (1 in.) steel plate 31 cm (12 in.) square for laminar discontinuities, which of the following would be most effective?
- Ir-192, 3.7 TBq (100 Ci).
 - Co-60, 925 GBq (25 Ci).
 - 250 kVp X-ray machine.
 - An ultrasonic device.
- RT-28 A critical weld was made with a double V-groove. Among those listed, which radiographic technique would provide coverage with the greatest probability for detecting the most serious discontinuities?
- A single exposure centered on the weld and perpendicular to the principal surface of the plate.
 - Two exposures aligned with the V-groove focus, $\pm 30^\circ$ off perpendicular.
 - Two exposures, perpendicular to the plate, offset by the width of the weld bead.
 - A single exposure as in a, above, but with two films aligned $\pm 30^\circ$ off perpendicular.
 - Both a and d would produce the best coverage.
- RT-29 A fuse assembly is being radiographed so that measurements can be made on the film to determine a minimum internal clearance dimension. What should be factored into the dimension taken from the film?
- Projection magnification.
 - Unsharpness factors.
 - Precision of X-ray beam alignment.
 - Both a and c.
 - All of the above.
- RT-30 Miniature electronic components are to be radiographically inspected to reveal broken copper wire leads of 0.2 mm (0.008 in.) diameter. Which of the following image quality indicators (IQI) would be most effective to use in establishing a reliable technique?
- A series of steel plaque-type penetrameters ranging in thickness from 0.1 mm (0.005 in.) to 0.4 mm (0.015 in.), containing 1T, 2T, and 4T holes.
 - A plastic block with the radiographic thickness equivalent of the test objects, containing precision-drilled holes ranging from 0.1 mm (0.005 in.) to 0.4 mm (0.015 in.) diameter.
 - A plastic block with the radiographic thickness equivalent of the test objects, containing copper wires ranging from 0.1 mm (0.005 in.) to 0.4 mm (0.015 in.) diameter.
 - A series of copper shims ranging in thickness from 0.1 mm (0.005 in.) to 0.4 mm (0.015 in.), containing 1/2T and 1T holes.

Ultrasonic Testing (UT)

Topical Outline

1.0 Fundamentals

1.1 Ultrasonic soundbeams

- Wave travel modes
- Refraction, reflection, scattering, and attenuation

1.2 Transducers and soundbeam coupling

1.3 Resonance

- 2.0 Ultrasonic Testing
- 2.1 Basic types of equipment
 - 2.2 Reference standards
 - 2.3 Test result interpretation; discontinuity indications
 - 2.4 System factors
 - 2.5 Applications
 - a. Flaw detection
 - b. Thickness measurement
 - c. Bond evaluation
 - d. Process control
 - e. Field inspection

Reference

Birks, Albert S. and Robert E. Green, Jr., technical eds., Paul McIntire, ed. Volume 7, *Ultrasonic Testing*. Columbus, OH: The American Society for Nondestructive Testing, Inc. 1991.

Review Questions

- UT-1 Ultrasonic waves propagate through test materials in the form of:
- a. electromagnetic waves.
 - b. low voltage electric fields.
 - c. discontinuous radio waves.
 - d. radiation.
 - e. mechanical vibrations.
- UT-2 When an ultrasonic beam passes through the interface of two dissimilar materials at an angle, a new angle of sound travel takes place in the second material due to:
- a. attenuation.
 - b. rarefaction.
 - c. compression.
 - d. refraction.
- UT-3 The gradual loss of energy as ultrasonic vibrations travel through material is referred to as:
- a. reflection.
 - b. refraction.
 - c. reproducibility.
 - d. attenuation.
 - e. compression.
- UT-4 Ultrasonic velocities are different for different materials. These differences are primarily caused by differences in the materials':
- a. frequency and wavelength.
 - b. thickness and travel time.
 - c. elasticity and density.
 - d. chemistry and permeability.
- UT-5 Ultrasonic energy for immersion testing is transmitted to the test object as a compressional wave because:
- a. compressional waves travel faster and will therefore reduce the distance of the interface signal.
 - b. liquids will only sustain compressional waves.
 - c. compressional waves are used with immersion testing only.
 - d. the higher intensity of compressional waves is necessary to overcome high attenuation in liquids.
- UT-6 When inspecting coarse-grained materials, which of the following frequencies will generate a sound wave that will be most easily scattered by the grain structure?
- a. 1.0 MHz.
 - b. 2.25 MHz.
 - c. 5 MHz.
 - d. 10 MHz.
- UT-7 In general, shear waves are more sensitive to small discontinuities than longitudinal waves for a given frequency and in a given material because:
- a. the wavelength of shear waves is shorter than the wavelength of longitudinal waves.
 - b. shear waves are not as easily dispersed in the material.
 - c. the direction of particle vibration for shear waves is more sensitive to discontinuities.
 - d. the wavelength of shear waves is longer than the wavelength of longitudinal waves.

- UT-8 The ability of transducers to detect echoes from small discontinuities is a definition for:
- resolution.
 - sensitivity.
 - definition.
 - gain.
 - selectivity.
- UT-9 Which of the following will create a resonance condition in a specimen?
- Pulsed longitudinal waves.
 - Continuous longitudinal waves.
 - Pulsed shear waves.
 - Continuous shear waves.
 - All of the above.
- UT-10 The display on most basic pulse-echo ultrasonic instruments consists of:
- automatic read-out equipment.
 - an A-scan presentation.
 - a B-scan presentation.
 - a C-scan presentation.
- UT-11 In a basic pulse-echo ultrasonic instrument, the component that produces the voltage that activates the search unit is called:
- an amplifier.
 - a receiver.
 - a pulser.
 - a synchronizer.
- UT-12 The primary purpose of reference blocks is to:
- aid the operator in obtaining maximum back reflections.
 - obtain the greatest sensitivity possible from an instrument.
 - obtain a common reproducible reference standard.
 - enable testing of nonmetals.
 - establish the size and orientation of a discontinuity.
- UT-13 The general use of distance-amplitude calibration is to compensate for:
- amplitude of noise signals.
 - velocity changes.
 - transducer size.
 - attenuation, distance, and beam spread.
 - vertical nonlinearity in the ultrasonic instrument.
- UT-14 In area-amplitude ultrasonic standard test blocks, the flat-bottomed holes in the blocks are:
- all the same diameter.
 - different in diameter, increasing in 0.4 mm (0.02 in.) increments from the No. "1" block to the No. "8" block.
 - largest in the No. "1" block and smallest in the No. "8" block.
 - drilled to different depths from the front surface of the test block.
- UT-15 The amount of energy reflected from a discontinuity is dependent on:
- the size of the discontinuity.
 - the orientation of the discontinuity.
 - the type of the discontinuity.
 - all of the above.
 - only a and b.
- UT-16 The presence of a discontinuity will not produce a specific discontinuity indication on the CRT screen when which of the following techniques is being used?
- Straight beam testing.
 - Surface wave testing.
 - Angle-beam testing.
 - Through-transmission testing.
 - Pulse-echo technique.

- UT-17 Lack of parallelism between the entry surface and the back surface:
- may result in a screen pattern that does not contain back reflection indications.
 - makes it difficult to locate discontinuities that lie parallel to the entry surface.
 - usually indicates a porous condition existing in the metal.
 - will decrease the penetrating power of the test.
- UT-18 Significant errors in ultrasonic thickness measurement can occur if:
- test velocity is varied.
 - the velocity of propagation deviates substantially from an assumed constant value for a given material.
 - water is used as a couplant between the transducer and the part being measured.
 - longitudinal waves are used.
- UT-19 In contact testing, shear waves can be induced in the test material by:
- placing an X-cut quartz crystal directly on the surface of the materials, and coupling through a film of oil.
 - using two transducers on opposite sides of the test specimen.
 - placing a spherical acoustic lens on the face of the transducer.
 - using an "angle-beam transducer" with the transducer mounted on a plastic wedge so that sound enters the part at an angle.
- UT-20 The most commonly used method of producing shear waves in a test part when inspecting by the immersion method is by:
- transmitting longitudinal waves into a part in a direction perpendicular to its front surface.
 - using two crystals vibrating at different frequencies.
 - using a low frequency transducer.
 - angulating the search tube to the proper angle with respect to the entry surface of the test part.
- UT-21 In immersion testing, proof that the search unit is normal to a flat entry surface is indicated by:
- maximum reflection amplitude from the entry surface.
 - elimination of water multiples.
 - maximum reflection amplitude from the back surface.
 - maximum amplitude of the initial pulse.
 - maximum amplitude from a discontinuity indication.
- UT-22 In immersion testing, the water distance between the search unit and the test piece:
- should be as small as possible.
 - will have no effect on the test.
 - should be the same as the water distance used during calibration.
 - should be as great as possible.
- UT-23 Generally, the best ultrasonic testing technique for detecting discontinuities oriented along the fusion zone in a welded plate is:
- an angle-beam contact method employing surface waves.
 - a contact test using a straight longitudinal wave.
 - an immersion test using surface waves.
 - a resonance technique.
 - an angle-beam method using shear waves.

- UT-24 Thin sheet may be inspected for laminar discontinuities with the ultrasonic wave directed normal to the surface by observing:
- the amplitude of the front surface reflection.
 - the multiple reflection pattern.
 - the amplitude of the initial pulse.
 - signals that "walk" or move along the time base as the transducer is scanned over the sheet.
- UT-25 Ultrasonic inspection of castings is occasionally impractical because of:
- extremely small grain structure typical in castings.
 - coarse grain structure.
 - uniform flow lines.
 - random orientation of discontinuities.
- UT-26 Angle-beam testing of plate will often miss:
- cracks that are perpendicular to the sound wave.
 - inclusions that are randomly oriented.
 - laminations that are parallel to the front surface.
 - a series of small discontinuities.
- UT-27 Reflection indications from a weld area being inspected by the angle-beam technique may represent:
- porosity.
 - cracks.
 - weld bead.
 - all of the above.
 - only a and b.
- UT-28 An ultrasonic test using a straight beam contact search unit is being conducted through the thickness of a flat part such as plate. This test should detect:
- laminar type flaws with major dimensions parallel to the plane of the rolled surface.
 - transverse type flaws with major dimensions at right angles to the plane of the rolled surface.
 - radial flaws with major dimensions along the length but radially oriented to the rolled surface.
 - none of the above.
- UT-29 The resonance technique of thickness measurement has been mostly replaced by:
- through-transmission longitudinal wave techniques.
 - single sideband antiresonance techniques.
 - acoustic emission monitoring.
 - pitch and catch shear wave techniques.
 - linear time base pulse-echo techniques.
- UT-30 Ultrasonic testing techniques are useful in testing laminate and sandwich construction test objects for:
- paint thickness.
 - bond integrity.
 - leakage.
 - surface roughness.
 - electrical conductivity.
- UT-31 Ultrasonic techniques are frequently used in on-line automatic process control applications to measure and control:
- moisture content in food.
 - surface roughness of turbine blade castings.
 - chemical activity in chemical etching processes.
 - the density of forgings.
 - the thickness of cold rolled strip, sheets, and plates.

- UT-32 Which of the following statements about field inspection applications of ultrasonic testing is true?
- Because the equipment is large and bulky, field inspections are difficult, at best.
 - Aircraft and other field maintenance inspections usually require three persons; one to manipulate the transducer, one to monitor the instrument, and one to record results.
 - Digital displays must be used for outdoor inspection because of the limited brightness of CRT displays.
 - Field inspections are limited to discontinuity detection by contact techniques only.
 - None of the above statements is true.

Vibration and Analysis Testing (VA)

Topical Outline

1.0 Principles/Theory

"The vibration data provides detailed information about the condition of a machine and its components. Data can be processed and presented in different ways to help the analyst in diagnosing specific problems. The section on principles and theory and provides the concepts of vibration analysis."

1.1 Physical concepts

- Sources of vibration
- Stiffness
- Mass
- Damping
- Phase
- Modes of vibration
- Resonance

1.2 Data presentation

- Units of measurement of spectrum
- Waveform
- Phase analysis

1.3 Sources of vibration

- Reciprocating machinery analysis
- Specialty machine concepts

1.4 Correction methods

- Absorbers
- Damping treatments

2.0 Equipment

"This section under equipment includes instrumentation, sensors, and cabling used in vibration analysis."

2.1 Sensors

- Attachments (brackets, connectors, sensor mounting)
- Cabling

2.2 Signal conditioning

2.3 Instruments

- Recorders
- Analyzers
- Oscilloscopes
- Multi channel

2.4 On-line monitoring

2.5 Equipment response to environments (performance based)

3.0 Techniques/Calibration

"Description of ways in which vibration analysis equipment can be used to perform vibration measurements and to analyze the results. This includes routine field Calibration and Correction of measured data due to effects of test equipment."

3.1 Calibration

- Point sensor calibration/verification
- Instrument calibration/verification
- Test instrument calibration/verification

3.2 Measurement and techniques

- Low speed
- High speed
- Variable
- Order tracking
- Time synchronous analysis
- Cross channel measurements
- Transient analysis
- Modal analysis fundamentals
- Operating deflection shape analysis
- Natural frequency tests
- Torsional vibration techniques
- Specialized vibration analysis techniques (demodulated spectrum, spike energy spectrum, etc.)

3.3 Correction techniques

(vibration correction techniques)

- 4.0 Analysis/Evaluation
 "Ability to analyze test data, perform an Evaluation and recommend remedial action."
- 4.1 Data analysis
- 4.1.1 Operational effects
 - 4.1.2 Correlation of test data
 - 4.1.3 Transient analysis
 - 4.1.4 In-depth time waveform analysis
 - 4.1.5 Cross channel analysis
 - 4.1.6 Multichannel analysis
 - 4.1.7 Machinery specific analysis
- 4.2 Data evaluation
- 4.2.1 Evaluation of data to standards/codes
 - 4.2.2 Specifications or acceptance criteria
 - 4.2.3 Failure mode and effects analysis
 - 4.2.4 Root cause analysis
 - 4.2.5 Cost justification or return on investment analysis
- 5.0 Procedures
 "To be able to develop procedures for performing the various types of testing techniques needed to determine equipment condition."
- 6.0 Safety and health
 "Working in close proximity to operating equipment containing a great deal of energy, special care must be taken to avoid injury in addition to using specific personal protective equipment."

References

- Crawford, Arthur R. *The Simplified Handbook of Vibration Analysis*, Volume I, *Introduction to Vibration Analysis*. Knoxville, TN: CSI. 1992.
- Crawford, Arthur R. *The Simplified Handbook of Vibration Analysis*, Volume II, *Applied Vibration Analysis*. Knoxville, TN: CSI.

Review Questions

Vibration and analysis review questions were not yet available at the time of this printing.

Visual and Optical Testing (VT)

Topical Outline

- 1.0 Fundamentals
- 1.1 Principles and theory of visual testing
 - 1.2 Selection of correct visual technique
 - 1.3 Equipment and materials
- 2.0 Specific applications
- 2.1 Metal joining processes
 - 2.2 Pressure vessels
 - 2.3 Pumps
 - 2.4 Valves
 - 2.5 Bolting
 - 2.6 Castings
 - 2.7 Forgings
 - 2.8 Extrusions
 - 2.0 Microcircuits
- 3.0 Interpretation and evaluation
- 3.1 Codes and standards
 - 3.2 Environmental factors

References

- Allgaier, Michael W. and Stanley Ness, technical eds.; Paul McIntire and Patrick Moore, eds. *Nondestructive Testing Handbook*, second edition: Volume 8, *Visual and Optical Testing*. Columbus, OH: The American Society for Nondestructive Testing, Inc. 1993.

Review Questions

- VT-1 What is considered the typical spectral range of visible light for most humans?
- a. 300-800 nm.
 - b. 380-770 nm.
 - c. 400-800 nm.
 - d. 250-920 nm.
- VT-2 What element of the eye functions the same as the photographic plane of a camera?
- a. The optic nerve.
 - b. The iris.
 - c. The cornea.
 - d. The retina.

- VT-3 A surface has diffuse reflection when:
- a fuzzy reflection of the light source is seen.
 - a perfect reflection of the light source can be seen.
 - no reflection of the light source is seen.
 - none of the above.
- VT-4 The resolution of the human eye at a distance of about 31 cm (12 in.) is nearest:
- 0.03 mm (0.001 in.)
 - 0.08 mm (0.003 in.)
 - 0.3 mm (0.010 in.)
 - 1.3 mm (0.050 in.)
- VT-5 For routine visual inspection, the eye should be located at a distance:
- between 15 cm and 152 cm (6 and 60 in.)
 - less than 25 cm (10 in.)
 - between 31 and 60 cm (12 and 24 in.)
 - more than 60 cm (24 in.)
- VT-6 The angle the eye makes with respect to the normal to the inspection surface should not:
- exceed 70 degrees.
 - exceed 45 degrees.
 - exceed 5 degrees.
 - be considered.
- VT-7 The minimum lighting condition recommended for detecting cracks in welds is:
- 100 lx.
 - 200 lx.
 - 500 lx.
 - 2,000 lx.
- VT-8 What is the name of the condition of eye adaptation to a dark environment?
- Photopic vision.
 - Stereotopic vision.
 - Scotopic vision.
 - Heliotopic vision.
- VT-9 The spectral range of visible response in humans is:
- static.
 - dependent on lighting conditions.
 - greatest at wavelengths less than 400 nm.
 - greatest at wavelengths more than 750 nm.
- VT-10 The IES is the:
- International Eye Society.
 - Institute of Engineering Sciences.
 - Illumination and Eyesight Society.
 - Illuminating Engineering Society.
- VT-11 The eye is functionally blind when it is:
- in the mesopic vision state.
 - moving between observation points.
 - filled with tears.
 - none of the above.
- VT-12 When looking for surface conditions, the illumination angle should be:
- between 5 and 45°, measured from the normal.
 - between 20 and 60°, measured from the normal.
 - between 20 and 45°, measured from the part surface.
 - between 5 and 45°, measured from the part surface.
- VT-13 Fluorescence is defined as:
- glowing in the dark.
 - absorbing and emitting light at different wavelengths.
 - absorbing and emitting light at the same wavelength.
 - emitting light as a result of nuclear bombardment.

- VT-14 Effective visual inspection relies on which of the following factors?
- An awareness of the possible causes of defects.
 - An awareness of how the part has been used.
 - Precleaning and environmental factors such as temperature and noise.
 - All of the above.
- VT-15 Pilling found when inspecting aircraft skins is usually attributed to:
- misalignment of fasteners used to attach the skins to the airframe.
 - expansion of corrosion products under the skins.
 - stretching of the skins beyond their yield points over time.
 - twisting of the airframe during tight turns and similar maneuvers.
- VT-16 When inspecting extrusions for excessive draw marks under a pair of long fluorescent tubes:
- it is best to align the probable direction of the draw marks parallel to the tubes.
 - it is best to align the probable direction of the draw marks perpendicular to the tubes.
 - the orientation of the draw marks is unaffected by the diffuse lighting from such tubes.
 - it is unlikely that such conditions can be found using fluorescent tubes for illumination.
- VT-17 *In-situ* detection of creep degradation in high-temperature, high pressure piping materials is found using:
- remote infrared scanning techniques.
 - a borescope while scanning from inside the pipe.
 - fluorescent penetrant leakage.
 - magnified surface contour replications.
- VT-18 The heat affected zone (HAZ) of carbon steel welds is made visible through the use of:
- etchants to enhance the visibility of the microstructure.
 - high frequency ultrasonic microscopic means.
 - color contrast penetrating liquids.
 - arrays of temperature-sensitive markings.
- VT-19 Inspection schemes that rely on optical interference patterns include:
- holography, photography, and optical microscopy.
 - shearography, telescopy, and image diffraction.
 - Schlicren photography, moiré imagery, and optical microscopy.
 - moiré imagery, holography, and interferometry.

Section 3

Section 3

Section 3

Materials and Processes for NDT Technology

Reference

Materials and Processes for NDT Technology. Columbus, OH: The American Society for Nondestructive Testing, Inc. 1981.*

*This reference is available from ASNT.

Chapter 6

Materials and Processes for NDT Technology

Overview of Materials and Processes for NDT Technology

Commensurate with the need for NDT Level III personnel to have basic knowledge of materials and processes, a book was written specifically for the purpose of presenting the fundamentals of materials and processes in NDT. Clearly, not all NDT Level III personnel need to specialize in depth in more than a few facets of materials and processes technology. However, the relationships between NDT technology and materials and processing are pervasive. NDT personnel charged with the responsibilities of selecting appropriate NDT methods, developing techniques and procedures, and directing the efforts of others in providing meaningful and reliable NDT must have a fundamental and broad knowledge of the origins, nature, behavior, and application of materials and the processes by which they are shaped into the products of today's commerce.

The importance of the relationships between NDT and materials and processing technology is characterized in the ASNT Level III Basic Examination. Approximately one-third of the Basic Examination covers basics and fundamentals of materials and processes technology. Listed on the following pages are sample questions typical of those that have importance to NDT personnel. Note that most have an underlying basis that ties their content to decision points in NDT.

Some NDT Level III personnel are not used by their employers in work assignments that require significant knowledge of materials and

processing technology. However, progression in NDT technology from Level II to Level III in most industrial and commercial situations does require the individual to be able to respond to more complex technical questions, not only about the details of NDT, but about more and more details related to causes and effects. Imagine being called upon to select NDT methods, develop techniques and procedures, and instruct others in carrying out an inspection of a critical component without knowing whether the component was a casting, forging, or weldment. Even with the knowledge of the component's processing history, if the Level III lacks the knowledge of what could go wrong during that processing, how can the Level III be expected to render important decisions about what NDT should be used, and how NDT should be used?

So fundamental is this relationship that it is often overlooked; but so important is this relationship that the book, *Materials and Processes for NDT Technology*, was prepared and published in 1981. The questions here follow the chapters in this book.

As a suggestion in the use of these questions, try to answer the questions about a particular chapter before proceeding to the next chapter. If the subject material is unfamiliar, or if the questions are difficult to answer, read the chapter. The material in the book is presented specifically with the NDT technologist in mind. It is concise and well-illustrated, but it does not require an engineering or scientific background to be comprehended. Complex theories and unimportant details are not included.

Review Questions

Chapter 1, Relation of NDT to Manufacturing

- 1-1 Fracture is a type of material failure. Of the following, which is another type of material failure?
- Fracture mechanics.
 - Low frequency dynamic loading.
 - Permanent deformation.
 - Elongation within the elastic range.
 - None of the above.
- 1-2 Which of the following statements best differentiates between a defect and a discontinuity?
- Discontinuities can propagate and become defects.
 - All discontinuities are defects.
 - All defects will lead to failure if undetected; discontinuities can be harmless.
 - Discontinuities are external natural boundaries only; defects are internal flaws originating from errors in processing.
- 1-3 Nondestructive testing (NDT) is often differentiated from other measurements or inspection techniques in that:
- NDT involves indirect tests related to some other quality or characteristic of the material.
 - NDT is a measurement of dimensions, geometry, and appearance.
 - NDT uses electronic instruments to identify, evaluate, and locate discontinuities.
 - NDT is an inspection tool used to confirm the findings of the many other quality assurance techniques.
- 1-4 Which of the following describes a function of NDT?
- Identification and sorting of material.
 - Identification of material properties.
 - Assuring absence of faults or defects that could cause a part to fail.
 - All of the above.
- 1-5 An important basis for the success of fracture control design procedures is:
- that all flaws are detected by NDT or proof testing before the component enters service.
 - in the use of large factors of safety.
 - in the use of a value of strength that the material used in the design is presumed to possess.
 - the need to assure that unexpected flaws of some critical size are not present when the component enters service.
 - all of the above.
- 1-6 If properly used, NDT can assist in fracture control by:
- accurately measuring the tensile strength of design materials.
 - providing an accurate evaluation of the number and type of discontinuities that exist in a material.
 - predicting the time it will take a given size discontinuity to grow to a critical size.
 - all of the above.

1-7 A statement that a particular experiment produced a 0.9 probability of detection with a 95% confidence level means that:

- there is a 95% probability that the probability of detection is overstated.
- there is a 5% probability that the probability of detection is overstated.
- on the average, 90% of all flaws will be detected.
- on the average, 95% of all flaws will be detected.
- on the average, 95 out of 100 flaws will be detected 90% of the time.

Chapter 2, Introduction to Manufacturing Technology

2-1 Most solid metals and plastics that have reasonable strength at room temperature are called:

- composite materials.
- manufacturing materials.
- raw materials.
- allotropic materials.
- engineering materials.

2-2 Materials properties, as used in design, are most frequently determined by:

- theoretical analysis.
- materials testing.
- the National Institute of Standards and Technology (NIST).
- fracture mechanics testing.

2-3 Even at the early stages of product planning, NDT should be considered because:

- it may be required by codes and specifications.
- the design of the part should permit easy access to critical areas for later inspection.
- the materials selected should be compatible with a NDT technique that can accurately evaluate the product.
- all of the above.

Chapter 3, Properties of Materials

3-1 Which of the following materials properties are of most concern if corrosion resistance is essential?

- Processing properties.
- Mechanical properties.
- Physical properties.
- Chemical properties.

3-2 Which of the following is true relative to the comparison of the properties of aluminum-based alloys and iron-based alloys?

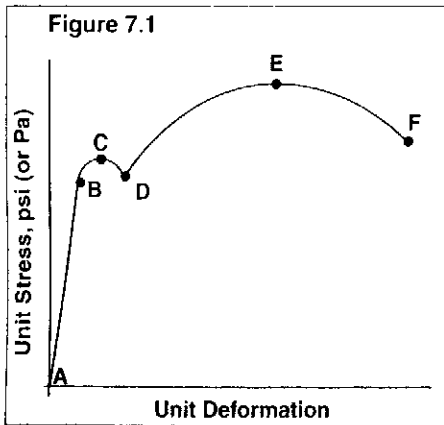
- Iron has a lower melting point than aluminum.
- Iron can exist in several different crystalline structures, and its properties can be controlled by heat treatment.
- Iron can be alloyed to increase its strength, whereas aluminum is strongest in its pure state.
- Iron is preferred in load carrying designs, but it should not be used for any deformation type of manufacturing process.
- All of the above.

3-3 Tensile tests are conducted on specimens from a newly developed alloy in order to determine the ultimate tensile strength of the material. Such tests are referred to as:

- indirect tests.
- physical properties tests.
- destructive tests.

3-4 A bar that is 31 cm (12 in.) long, 51 mm (2 in.) wide, and 25 mm (1 in.) thick is subjected to a tensile load acting along the length of the bar of 36,000 lbs. What is the tensile stress within the bar?

- 1,500 psi.
- 3,000 psi.
- 12,000 psi.
- 18,000 psi.
- 36,000 psi.



3-5 In Figure 7.1, point B is called the:

- elastic range.
- elastic limit.
- yield point.
- yield strength.
- modulus of elasticity.

3-6 In Figure 7.1, which of the following ranges indicate the effect of work hardening (to its maximum) caused by plastic flow of the material during a tensile load?

- A-B
- B-C
- C-D
- D-E
- E-F

3-7 In Figure 7.1, the points represented by E and F would be closer together if the material being tested were:

- loaded in tension.
- loaded in lapshear.
- more ductile.
- less ductile.

3-8 The modulus of elasticity, or Young's modulus, is a measure of the material's relative:

- tensile strength.
- compressive strength.
- resistance to stress.
- stiffness, yield strength.

3-9 Which of the following materials is typically considered when the application only requires high compressive strength?

- Low carbon steel.
- High carbon steel.
- Cast iron.
- Magnesium.

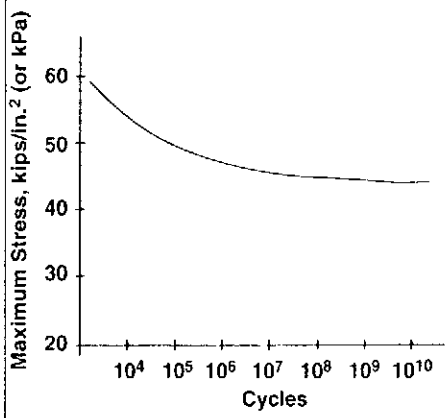
3-10 A fatigue failure can often be prevented by using NDT to:

- verify the cyclic loading on a component part.
- detect surface discontinuities that could be stress risers.
- measure the endurance limit of a part undergoing cyclic stresses.
- determine percent elongation of a material before it is placed in service.

3-11 Which of the following tests uses a pendulum to break a specimen that is notched and supported on both ends, with the result of measuring energy absorption?

- Creep test.
- Charpy test.
- Fatigue test.
- Transverse rupture test.

Figure 7.2



3-12 Figure 7.2 typifies:

- a creep test curve.
- an S-N curve.
- a stress-strain diagram.
- true stress-strain diagram.

3-13 Direct hardness tests provide a measure of a material's ability to resist:

- bending.
- surface and near-surface penetration.
- tensile stresses.
- elongation.

3-14 A particular type of steel has an ultimate strength of 80,000 pounds per square inch (psi), an elastic limit of 60,000 psi, and a yield strength of 62,000 psi. An allowable design stress of 20,000 psi is used. What is the factor of safety based on the ultimate strength?

- 0.25
- 0.33
- 3
- 3.1
- None of the above.

Chapter 4, The Nature of Materials and Solid State Changes in Metals

4-1 Under ordinary usage, metals exist as:

- amorphous solids.
- mixtures and compounds of iron and carbon.
- crystalline solids.
- face-centered cubic lattices.

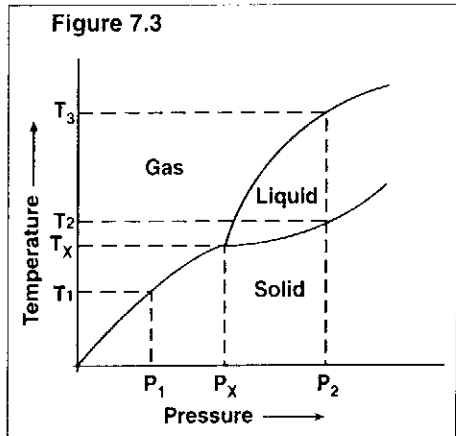
4-2 The terms "body-centered cubic," "face-centered cubic," and "hexagonal close-packed" all refer to the:

- different size grains that can exist at the same time in a metallic structure.
- sequence of crystalline growth in a typical mild steel.
- lattice structures that make up unit cells in a solid metallic structure.
- change in a metallic structure as it undergoes plastic deformation.

4-3 On Figure 7.3, which intersection describes the "triple point" of the material?

- (P_2, T_3)
- (P_2, T_2)
- (P_x, T_x)
- (P_1, T_1)
- None of the above.

Figure 7.3



- 4-4 The process of returning ductility to a cold worked low carbon steel is called:
- precipitation.
 - recrystallization.
 - allotropic change.
 - austenitization.
- 4-5 Many metals exhibit an increase in strength caused by plastic flow beyond the elastic limit. This effect is called:
- twinning.
 - plastic deformation.
 - work hardening.
 - recrystallization.
 - age hardening.
- 4-6 When used as in-process treatment, recrystallization can:
- improve ductility.
 - refine grains.
 - increase hardness.
 - result in both a and b above.
 - result in a, b, and c above.
- 4-7 Processes called austenitizing, annealing, normalizing, and spheroidizing are:
- performed only on nonferrous metals.
 - approximate equilibrium heat-treatment processes.
 - cold working processes.
 - age-hardening processes.
- 4-8 The term "precipitation hardening" is often used interchangeably with the term:
- age hardening.
 - recrystallization.
 - annealing.
 - work hardening.
 - plasticizing.
- 4-9 An NDT method that has the ability to measure changes in electrical conductivity caused by the effects of heat treatment is:
- magnetic particle testing.
 - acoustic emission testing.
 - eddy current testing.
 - immersion ultrasonic testing.
 - all of the above.
- 4-10 Spheroidizing and normalizing have the effect of:
- increasing ductility.
 - age hardening.
 - reducing the grain size.
 - causing a phase change.
- 4-11 When a steel has been quench-hardened and then reheated to some point below the lower transformation temperature for the purpose of reducing brittleness, this is called:
- austenitization.
 - thermal slip deformation.
 - allotropic change.
 - tempering.
- 4-12 Annealing is usually performed to:
- decrease hardness.
 - increase ductility.
 - relieve stresses.
 - both a and b.
 - all of the above.
- 4-13 Attacks on metals by direct chemical action and/or electrolysis are called:
- rust.
 - corrosion.
 - austenitic transformations.
 - galvanization.
- 4-14 Metal corrosion that is accelerated when the metal is under loads is called:
- pitting corrosion.
 - galvanic corrosion.
 - electrochemical corrosion.
 - stress corrosion.

- 4-15 Which of the following may be performed to help prevent corrosion?
- Stress relieving.
 - Anodizing.
 - Dipping in molten metal.
 - Electroplating.
 - All of the above.
- 4-16 Factors of safety are often in the range of 2 to 4; they:
- provide allowances for unexpected loads or conditions.
 - present problems in designing effective aircraft.
 - could be reduced with the assurance of NDT techniques that the material was free of discontinuities.
 - relate to all of the above.
- 5-3 Which of the following techniques is often used to speed-up the steel-making process?
- Adding large amounts of carbon to the molten metal.
 - Reducing the amount of scrap steel that is often added to the molten metal.
 - Adding oxygen to the molten metal.
 - Converting the old open-hearth furnaces into electric furnaces.
- 5-4 Typically, the highest quality of steel is produced in:
- an electric furnace.
 - an open-hearth furnace.
 - a Bessemer furnace.
 - a basic oxygen furnace.

Chapter 5, Ferrous Metals

- 5-1 The reduction of iron ore, by mixing with coke, limestone, and oxygen for combustion of the coke, is accomplished in:
- a blast furnace.
 - an open-hearth furnace.
 - a Bessemer converter.
 - a basic oxygen furnace.
- 5-2 In the iron and steel-making process, the term "pig iron" refers to:
- the waste material that contains high concentrations of impurities and slag and is either discarded or used as a by-product.
 - a high carbon, low ductility metal that is produced in the blast furnace which can be used to make subsequent types of iron and steel.
 - the molten metal from the blast furnace that is not usable and is poured off into a series of crude castings called "pigs."
 - both a and c.
 - none of the above.
- 5-5 What percentage of carbon is found in steel?
- Between 3% and 4%.
 - Between 2% and 3%.
 - Less than 0.2%.
 - Less than 2%.
- 5-6 By which of the following processes is most of the world's steel produced?
- Bessemer converter.
 - Electric furnace.
 - Open-hearth.
 - Crucible.
 - Basic oxygen.
- 5-7 An undesirable by-product of steel-making processes is:
- coke.
 - low carbon steel.
 - low alloy steel.
 - slag.
- 5-8 A steel with 40 points of carbon contains:
- 40% carbon.
 - 4% carbon.
 - 0.4% carbon.
 - 0.04% carbon.

- 5-9 Low carbon steel contains approximately:
- 0.6% to 2.5% carbon.
 - 0.06% to 0.25% carbon.
 - 0.5% to 1.6% carbon.
 - 5% to 16% carbon.
- 5-10 Corrosion-resistant steels having relatively high percentages of nickel and chromium are called:
- wrought iron.
 - low alloy steels.
 - stainless steels.
 - nonferrous steels.
- 5-11 Austenitic stainless steels are paramagnetic; this means that:
- alternating current must be used when using the magnetic particle testing method.
 - the steel is very dense and, relative to other steels, difficult to penetrate with X-rays.
 - ultrasonics is the logical NDT method to choose because of the coarse-grained nature of a paramagnetic material.
 - all of the above are true.
 - none of the above is true.
- 5-12 Which of the following is an advantage of cast steel over wrought steels?
- Cast steels usually have higher mechanical properties than wrought steels.
 - Cast steels have more isotropic properties than wrought steels.
 - Cast steels are more corrosion-resistant than wrought steels.
 - Cast steels cannot be heat-treated, and are thus less expensive to produce than wrought steels.

Chapter 6, Nonferrous Metals and Plastics

- 6-1 Which of the following nonferrous metals is the most important structural material?
- Copper alloys.
 - Nickel alloys.
 - Zinc alloys.
 - Aluminum alloys.
- 6-2 Which of the following statements is true regarding the electrical conductivity of aluminum alloys?
- Most aluminum alloys are in the range of 70% to 96% IACS.
 - Clad aluminum takes on the conductivity of the base metal.
 - Each basic wrought aluminum alloy has a conductivity distinct from any other.
 - Both a and b are true.
 - None of the above is true.
- 6-3 The heat treatment of aluminum for the purpose of hardening and strengthening:
- is not possible with aluminum alloys because they contain no carbon and cannot undergo allotropic changes.
 - can produce tensile strengths equivalent to some carbon steels.
 - requires the use of special furnaces and is rarely done as a practical application.
 - requires that iron and carbon be alloyed for the best results.
- 6-4 Which of the following metals has low strength, high corrosion resistance, and is used largely in die casting operations?
- Aluminum.
 - Magnesium.
 - Zinc.
 - Manganese.
- 8/1/83*
6/1/83
6/1/83

- 6-5 Which of the following metal alloys has a density approximately two-thirds that of aluminum?
- Magnesium.
 - Beryllium.
 - Copper.
 - Nickel.
- 6-6 Brass and bronze are alloys of zinc, tin, and a large percentage of:
- beryllium.
 - copper.
 - lead.
 - nickel.
- 6-7 Monel and Inconel are:
- nickel alloys.
 - steel alloys.
 - magnesium alloys.
 - aluminum alloys.
 - copper alloys.
- 6-8 Which of the following metals can typically be used in the as-cast state?
- Aluminum.
 - Zinc.
 - Steel.
 - Iron.
 - All of the above.
- 6-9 A high strength, low density, corrosion-resistant metal alloy of significance in the aircraft, marine, chemical processing industries is:
- tungsten.
 - zinc.
 - titanium.
 - magnesium.
- 6-10 Which of the following statements is true concerning plastics following their initial polymerization?
- Thermoplastics resoften when reheated.
 - Thermosetting plastics do not soften, but char and deteriorate when reheated.
 - All plastics are synthetic and contain no natural materials.
 - Both a and b are true.
 - All of the above are true.
- 6-11 Based on the strength-to-weight ratio:
- no plastic materials can compare with metals.
 - some plastics, including nylon, may have strengths greater than some steels.
 - plastics, as a group, are superior in strength to most ferrous metals.
 - none of the above are true.

Chapter 7, The Nature of Manufacturing

- 7-1 Design engineers are responsible for establishing the function, appearance, quality, and cost of a product. Regarding the role of NDT in product design, which of the following is true?
- As a group, designers (by their training and education) are adequately informed about NDT to establish NDT procedures and acceptance criteria.
 - When NDT appears necessary in a design, the designer should properly select the methods and techniques to be used by reference to NDT handbooks.
 - Designers should depend solely upon NDT personnel to establish acceptance criteria.
 - None of the above is true.

- 7-2 Manufacturing is a term that refers to processing that starts with raw material in a bulk form, and is concerned mainly with processing the raw material in a manner that changes:
- its shape.
 - its chemical form.
 - its mechanical properties.
 - its physical properties.
 - all of the above.
- 7-3 Manufacturing processes change raw material by:
- increasing the material's volume.
 - decreasing the material's volume.
 - solid deformation with no volume change.
 - both a and b.
 - all of the above.
- 8-3 Large voids or porosity in a casting results from:
- turbulent flow of the molten metal during pouring.
 - alloy element segregation.
 - molten metal boiling because of superheat.
 - gas evolution before and during solidification.
- 8-4 During the solidification of a casting, the shrinkage that occurs:
- may cause porosity and shrinkage cavities primarily in the outer surfaces where the metal cools first.
 - requires that the pattern used be slightly smaller than the desired dimension of the finished casting.
 - may cause cavities that are enlarged by the evolution of gases.
 - may result from all of the above.

Chapter 8, The Casting Process

- 8-1 Which of the following is true regarding solidification of molten metal in a casting mold?
- The metal cools at a constant rate, thus providing fine equiaxed grains throughout.
 - Cooling takes place in phases having different rates that produce different types of grain structure in different sections of the casting.
 - Solidification occurs at a constant rate, beginning at the interior of the casting and progressing outward.
 - Thick sections tend to cool more rapidly than thin sections because thin sections consist mostly of fine equiaxed grains.
- 8-2 In a casting, shrinkage occurs:
- only after the transformation from liquid to solid.
 - only during the transformation from liquid to solid.
 - before, during, and after the transformation from liquid to solid.
 - only when the metal is in the liquid state.
- 8-5 The design of the casting is important because the quality of the finished product can be adversely affected by the:
- lack of molten metal to compensate for contraction.
 - location of the gate with reference to either progressive solidification or directional solidification.
 - the location of "hot spots" in areas of the casting that are isolated by thin sections.
 - all of the above.
 - none of the above.
- 8-6 The term used to describe a discontinuity in a casting that occurs when molten metal interfaces with already solidified metal with failure to fuse at the interface is:
- hot tear.
 - cold shut.
 - lack of fusion.
 - segregation.

- 8-7 The part of the casting where the gate or riser was attached:
- should be the area used to establish reference standards for future NDT examinations because this area will contain the best quality cast material.
 - provides the best quality material because of rapid cooling in this area.
 - should be the area that "freezes" first, thus preventing excessive shrinkage cavities.
 - may provide a concentration point for discontinuities.
- 8-8 Risers, feeders, or feed heads in castings serve to provide sources of molten metal to compensate for:
- misruns.
 - cold shuts.
 - hot tears.
 - dendritic grain growth.
 - shrinkage.
- 8-9 Green sand casting molds include:
- sand, clay, and water.
 - sand, wax, and solvent.
 - sand, refractory metals, and water.
 - sand, carbon, and green clay.
- 8-10 Mold material in the form of inserts that exclude metal flow and thus form internal surfaces or passages in a casting are called:
- chills.
 - chaplets.
 - cores.
 - patterns.
- 8-11 Small metal supports used to support and position cores become part of a casting by fusing with the molten metal. Such devices are called:
- core hangers.
 - chills.
 - chaplets.
 - risers.
 - patterns.
- 8-12 Which of the following may cause a discontinuity even though its intended purpose is to prevent shrinkage cavities by absorbing heat from the molten metal in the center of the casting?
- A riser.
 - A core.
 - An internal chill.
 - A chaplet.
- 8-13 Which of the following NDT methods can be commonly used to inspect castings for core shift and nonfused chaplets and used to determine that all core materials have been removed?
- Ultrasonic testing.
 - Magnetic particle testing.
 - Radiographic testing.
 - Eddy current testing.
 - All of the above.
- 8-14 Casting molds made by covering a heated metal pattern with sand that is mixed with particles of thermosetting plastic are called:
- green sand molds.
 - shell molds.
 - plaster molds.
 - die casting molds.
 - permanent molds.
- 8-15 Permanent molds are most frequently made of:
- ceramics.
 - fused sand and plastic.
 - metal.
 - plaster.
- 8-16 Another term for precision casting and the lost wax process is:
- investment casting.
 - die casting.
 - metal mold casting.
 - shell mold casting.

- 8-17 A casting process used to produce hollow products like large pipes and hollow shafts is:
- investment casting.
 - blow casting.
 - core casting.
 - centrifugal casting.
- 8-18 A casting process used to produce elongated shapes by drawing solidified metal from a water-cooled mold backed by molten metal is:
- centrifugal casting.
 - continuous casting.
 - draw casting.
 - extrusion.
- 9-4 Metallurgical effects in a weld, such as grain size variation and shrinkage, are similar to those that occur in:
- forgings.
 - castings.
 - extrusions.
 - hot-rolled plates.
- 9-5 Pressure welding can be accomplished with pressure alone, but what else is usually added?
- Heat.
 - Filler material.
 - Oxides.
 - Adhesives.

Chapter 9, The Welding Process

- 9-1 An assembly that has been created by joining two or more parts by one or more welds is called a:
- joint.
 - bonded structure.
 - weld.
 - weldment.
- 9-2 A general definition of welding describes the joining of two surfaces:
- with a filler metal that has a higher melting point than the base metal.
 - with a filler material that is different from the base material.
 - in a permanent union established by atom-to-atom bonds.
 - where both heat and pressure are necessary for permanent bonding.
- 9-3 Of the following, which is not a requirement for fusion bonding?
- Melting.
 - Atomic closeness.
 - Atomic cleanliness.
 - Pressure.
 - Both b and c.
- 9-6 Proper brazing depends upon numerous factors being controlled. Of the following, which is not appropriate?
- Proper joint fit-up and joint preparation.
 - Adequate heat to melt the braze filler metal.
 - Selection of proper braze filler metal.
 - Complete melting of the step metal and diffusion of the braze filler metal into the base metal.
 - All of the above.
- 9-7 Soldering, brazing, and braze welding all:
- have the same strength characteristics.
 - use a process where only the filler metal is actually melted.
 - are fusion-type weldments.
 - use liquid penetrant inspection to reveal porosity within the joint.

- 9-8 Due to high temperatures and rapid rate of cooling, the filler material used in fusion welds:
- is coated with an oxide to help reduce weld defects.
 - contains alloys that will help compensate for properties lost during the welding process.
 - is alloyed with nickel, copper, and carbon to eliminate cracking.
 - should be as close as possible to the same alloy content as the base material.
- 9-9 The uneven shrinkage and brittle structures that occur due to the rapid cooling of a weld can often be reduced by:
- preheating the weldment prior to welding.
 - using a filler metal with a higher carbon content than the base metal.
 - clamping the weldment in a rigid fixture.
 - overdesigning the size of the weldment to prevent shrinkage.
- 9-10 After welding, many steel weldments are heat treated to obtain more uniform properties between the weld and base metal and to relieve stress. Which heat treatment method is often used following welding?
- Tempering.
 - Martensitic aging.
 - Normalizing.
 - Spheroidizing.
- 9-11 Weldments subject to restraint during welding can develop high residual stresses. Unrestrained weldments can develop:
- geometric distortion.
 - high residual stresses.
 - cracking after the weld has cooled.
 - all of the above.
- 9-12 Welds and weldments have been known to develop cracks long after cooling but prior to being used in service. What is the principal cause for such cracks?
- Accelerated corrosion at high temperature.
 - Scattered porosity in the weld.
 - Improper selection of base material.
 - Excessive residual stresses.

Chapter 10, Welding Processes and Design

10-1 In arc welding, the electric arc is usually sustained between an electrode and the:

- welding machine.
- coating on the electrode.
- work piece.
- shielding gas.

10-2 Which of the following gases are most frequently used as shielding to provide an inert atmosphere in the vicinity of the weld?

- Argon, helium, and carbon dioxide.
- Neon, tritium, and helium.
- Sulphur dioxide, argon, and oxygen.
- Argon, nitrogen, and hydrogen.

10-3 When molten metal is transferred from the electrode to the weld zone, it can be shielded from the atmosphere by:

- the burning of coatings on the welding electrode.
- maintaining the arc beneath flux powders.
- the flow of a shielding gas around the arc.
- all of the above.

10-4 The burn-off rate and amount of spattering during the arc welding process can often be controlled by:

- proper post-heating of the entire weldment.
- frequent changing of the tungsten electrode.
- maintaining the longest arc length possible to reduce the heat in the weld zone.
- selecting the proper electrode polarity.

10-5 Which of the following welding processes uses a nonconsumable electrode with the arc maintained in an atmosphere of inert gas?

- Gas Tungsten Arc welding.
- Submerged Arc welding.
- Gas Metal Arc welding.
- Electroslag welding.

10-6 Shielding in the submerged arc welding process is provided by:

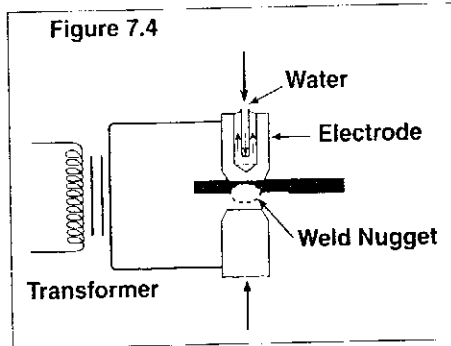
- gases.
- granular flux that completely surrounds the arc.
- a flux-coated welding rod.
- chopped glass fibers.

10-7 Which welding process is depicted in Figure 7.4?

- Electron-beam welding.
- Ultrasonic welding.
- Plasma arc welding.
- Resistance spot welding.
- Friction welding.

10-8 A welding process that is most frequently carried out in a vacuum chamber is:

- plasma arc welding.
- electron-beam welding.
- electroslag welding.
- friction welding.
- none of the above.



10-9 The welding process capable of very high intensity and rate of heat transfer is:

- braze welding.
- plasma arc welding.
- diffusion welding.
- soldering.

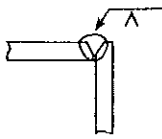
10-10 The welding process in which the arc is extinguished after melting a slag cover and in which the base metal and copper slides form a sort of moving mold is called:

- electroslag welding.
- submerged arc welding.
- electron-beam welding.
- slag-mold welding.

10-11 In the process of diffusion welding, often called diffusion bonding, the base metal is joined by:

- melting the weld joint area with strip heaters.
- using high temperature adhesives.
- putting it under pressure, at temperatures below the melting point.
- the heat of frictional movement between the surfaces to be joined.
- detonating explosives covering the materials to be joined.

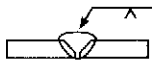
Figure 7.5



10-12 What type of weld joint is depicted in Figure 7.5?

- Butt joint.
- Tee joint.
- Lap joint.
- Corner joint.
- Edge joint.

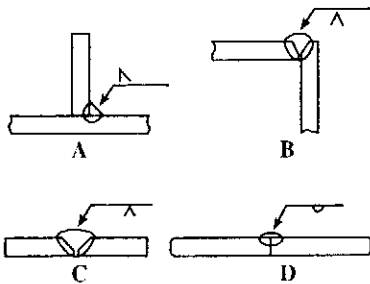
Figure 7.6



10-13 What type of weld joint preparation is shown in Figure 7.6?

- J-groove.
- Double J-groove.
- U-groove.
- Cup groove.
- Buttress groove.

Figure 7.7



10-14 In Figure 7.7, which sketch contains an incorrect welding symbol with respect to the weld joint shown?

- A
- B
- C
- D

10-15 A slag inclusion can result from which of the following?

- Small pieces of tungsten being dislodged from the electrode in the gas tungsten arc process.
- Insufficient cleaning of successive passes in a multipass weldment.
- Excessive undercut on intermediate passes in a multipass weldment.
- All of the above.
- Only b and c.

10-16 Undercut on a weld pass is usually caused by:

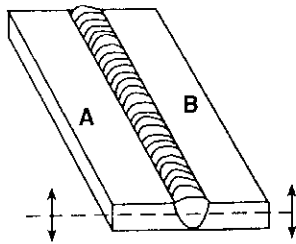
- poor operator technique.
- a rate of travel that is too slow, which causes the base metal to become too hot.
- the use of an electrode that is too large for the current capacity of the welding machine.
- all of the above.
- only b and c.

10-17 Crater cracks may take the form of a single crack or star-shaped cracks and will usually be found:

- by magnetic particle techniques since crater cracks are always subsurface.
- anywhere along a weld where the welding was stopped and restarted.
- in the natural crater formed between the two plates in a typical fillet weld.
- in the root area of a multiple pass weld where the weld metal failed to flow completely into the root opening.

- 10-18 The principal purpose of preheat treatment and post-heat treatment in welds is to:
- reduce the probability of formation of porosity in the weld.
 - neutralize residual stresses and geometric distortion.
 - create grains in the weld that are the same as those in the base metal.
 - cause the weld ripple and reinforcement to blend into the base metal.
- 10-19 In welding, the most obvious defects are those associated with structural discontinuities in the weld itself. Other conditions that can also be considered as defects are:
- improper weld dimensions and profiles.
 - base metal irregularities that have been enlarged by welding stresses and distortion.
 - structurally sound welds, but those with inadequate properties caused by errors in filler metal selection.
 - both a and c.
 - all of the above.

Figure 7.8



- 10-20 If the V-groove weld shown in Figure 7.8 was made in multiple passes and not clamped or restrained, typical warping would take place in which direction?
- Edges A and B would be lowered due to the expansion of the weld metal in the weld zone.
 - Edges A and B would be raised due to the contraction of the weld metal.
 - In a multipass weld, there would be little if any warpage.
 - Expansion and contraction would be equal in a V-groove weld as shown.
- 10-21 Cracks in the weld metal are primarily of which three types?
- Shallow, deep, and intermittent.
 - Longitudinal, transverse, and crater.
 - Laminar, through, and oblique.
 - Longitudinal, laminar, and intermittent.
- 10-22 Thermal conductivity of a metal is an important factor to consider in making quality weldments because:
- some metals, such as aluminum, have a low conductivity, which results in weld defects due to localized heat build-up.
 - some metals, such as stainless steel, have a high conductivity, which results in lack of fusion defects as the heat is quickly removed from the weld zone.
 - in some metals, such as aluminum, very high temperature gradients are produced, causing stresses during cooling.
 - all of the above.
 - none of the above.

Chapter 11, Plastic Flow

- 11-1 Deformation of metals provides a number of advantages. Which of the following is not an advantage?
- Deformation processes increase the probability of defect formation.
 - High duplication accuracy results from most deformation processes.
 - In general, the properties of wrought metals are improved over their cast counterparts.
 - Thin sections can be more economically and more successfully produced than by casting.
- 11-2 Among other things, the advantageous effects of recrystallization depend upon:
- the rate of deformation.
 - the temperature at which deformation takes place.
 - the presence of carbon in excess of 2.5% for steels.
 - all of the above.
 - both a and b.
- 11-3 Wrought products invariably exhibit:
- high susceptibility to corrosion.
 - lower strength than their cast counterparts.
 - directional properties.
 - poor weldability.
 - poor surface finishes unless machined.
- 11-4 During the steel-making process, a large number of faults such as slag, porosity, and shrinkage cavities exist in the top of the ingot. These discontinuities are:
- mostly eliminated in subsequent hot working due to the pressure that "welds" the void shut.
 - located with NDT techniques at later stages of production.
 - almost nonexistent with modern steel-making processes.
 - removed by cropping up to one-third off the top of the ingot.
- 11-5 Discontinuities with their origin in the original ingot can be reduced in severity by the closing and welding of voids and the breaking up and elongation of inclusions by which of the following processes?
- Cold working.
 - Hot working.
 - Heat treatment.
 - Welding.
- 11-6 Which of the following would have the least ductility?
- Cold rolled steel plate.
 - Hot rolled steel plate.
 - Gray cast iron.
 - Hot rolled aluminum plate.
- 11-7 A NDT technique best suited to locating discontinuities caused by inclusions rolled into steel plate is:
- radiographic inspection.
 - ultrasonic inspection.
 - visual inspection.
 - magnetic particle inspection.
- 11-8 Which of the following statements is true concerning deformation processes?
- Hot working usually follows cold working.
 - Hot working must be followed by heat treatment.
 - Hot worked materials must be cold worked before they can be used.
 - Cold working usually follows hot working.
 - Cold working renders brittle material more ductile.
- 11-9 Machinability and fatigue resistance are improved in most metals that have been:
- hot worked.
 - cold worked.
 - heat treated.
 - cast.

Chapter 12, Millwork, Forging, and Powder Metallurgy

- 12-1 NDT is often used just following hot and cold working operations to:
- assure that further operations are not performed on material that contains defects that could reject the manufactured part.
 - determine that defects do not exist in the material that could damage the rolling mills and other equipment.
 - determine the ductility of the material after the rolling operation is complete.
 - accurately determine the compressive strength of the material after it passes through the rolling mill.
- 12-2 Slabs, blooms, and billets are:
- the three consecutive stages that the metal goes through during the production of products such as angle iron and channel iron.
 - the shapes that the ingot is rolled into prior to a variety of secondary operations.
 - types of defects that occur during the hot rolling of steel.
 - the three different shapes produced during typical cold rolling operations.
- 12-3 Cold rolling sheet steel usually begins with a material that:
- has been completely inspected with an automated radiography system.
 - has been previously hot-rolled to dimensions close to the size of the finished product.
 - has less ductility and greater hardness than typical hot rolled steel.
 - will have a lower yield and tensile strength after cold working.
- 12-4 Before cold finishing operations can be done on hot rolled materials, cleaning is often done by immersing the hot-rolled material in acid baths in a process called:
- degreasing.
 - descaling.
 - anodizing.
 - pickling.
 - galvanizing.
- 12-5 The millworking process performed principally on flat products and bars that improves hardness, strength, surface finish, and dimensional accuracy is:
- cold rolling.
 - hot rolling.
 - forging.
 - extrusion.
 - sintering.
- 12-6 Most steel pipe is produced by forming and:
- drawing.
 - welding.
 - extrusion.
 - casting.
 - pressing.
- 12-7 Most seamless tubing made without welds is processed by:
- forging.
 - casting.
 - piercing.
 - cold rolling.
 - brazing.
- 12-8 A process that requires the use of large powerful equipment that forms ductile material into a wide variety of long length uniform cross sectional shapes best describes:
- forging.
 - powder metallurgy.
 - extrusion.
 - die casting.

- 12-9 The millworking process used most to form metals into three-dimensional shapes is:
- casting.
 - cold rolling.
 - welding.
 - forging.
- 12-10 Which of the following product forms is generally selected for high strength and controlled property directionality?
- Castings.
 - Extrusions.
 - Hot-rolled flat stock.
 - Forgings.
 - None of the above.
- 12-11 Powder metallurgy provides two unique advantages in metals processing. One is the capability to produce shapes and objects of refractory metals that are extremely difficult or impractical to melt; the other is to:
- economically produce metals with extremely low melting temperatures.
 - produce metal shapes with controlled porosity.
 - produce metals that can be easily machined by electrochemical processes.
 - produce metals that are corrosion resistant.
- 12-12 A major purpose of pressing the metal powders during powder metallurgy processing is to:
- squeeze out excess moisture.
 - further refine the grains.
 - compact the powders into mechanical and atomic closeness.
 - provide all of the above.
- 12-13 In the powder metallurgy process, sintering is:
- in most cases, a fully solid-state process.
 - never a fully solid-state process.
 - principally done at room temperature.
 - always done at elevated temperature and high pressure.
- 12-14 Powdered metallurgy products cannot:
- be hot worked after sintering.
 - be heat treated after sintering.
 - be machined after sintering.
 - attain 100% of theoretical density.
 - be subjected to any of the processes mentioned above.
- 12-15 Which of the following is an application for powdered metal products?
- Cemented carbide cutting tools and dies.
 - Tungsten rocket nozzles.
 - Oil-impregnated bushings.
 - Both b and c are applications.
 - All of the above are applications.

Chapter 13, Pressworking of Sheet Metal

- 13-1 Which of the following terms describe operations that bend, stretch, and shape sheet metals into three-dimensional shapes without significant plastic flow and deformation?
- Bending.
 - Forming.
 - Drawing.
 - Only a and b.
 - All of the above.

13-1
13-1
24, 4, 8:00 563

- 13-2 In drawing and deep drawing, the final shape often can be completed in a series of draws, each successively deeper. What process performed between draws might effectively reduce the number of draws required?
- Recrystallization.
 - Pickling.
 - Etching.
 - Hardening heat treatment.
 - Hot rolling.
- 13-3 Spinning can be used to form:
- spherical tank halves.
 - cemented carbide cutting tools.
 - crane hooks.
 - rectangular sheet metal tanks.
 - solid spheres.
- 13-4 Most new developments in sheet metal forming typically use nonconventional energy sources. What is a common feature of these processes?
- The use of lasers for controlled heat input.
 - The use of cryogenics to super-cool the metal prior to forming.
 - The use of energy sources that release large amounts of energy in a very short time.
 - The use of large autoclaves that contain both the tooling and the metal being formed.
- 14-2 In describing machinability, three different measurements are generally considered on a relative, if not quantitative, basis. These are:
- shear, tensile, and impact strength of the material being machined.
 - surface finish of the material achievable, power consumption required to remove a given volume of material, and expected tool life.
 - softness of the material, sharpness of the cutting tool, and type of machine used to remove the material.
 - volume of material before machining, volume of material after machining, and time required to remove that volume.
- 14-3 When used with respect to machine tools, the acronym N/C means:
- nonmetal cutters.
 - noncorrosive coolant.
 - numerical control.
 - nonconventional.
 - negative clearance.
- 14-4 Which of the following can result in economical set-up and reduced machine time with an increase in repeatability and accuracy for a variety of machining operations?
- The use of NDT to evaluate the finished product.
 - The use of electrical discharge machining to replace the conventional lathes and surface grinders.
 - The use of modern ultrasonic machining operations.
 - The use of numerical control systems applied to conventional types of machining operations.

Chapter 14, Machining Fundamentals

- 14-1 Machines designed to hold a cutting tool and a workpiece and establish a suitable set of motions between them to remove material from the workpiece are called:
- mill-working machines.
 - factory machines.
 - machine tools.
 - metal-cutting machines.

Chapter 15, Miscellaneous Processes

- 15-1 Which of the following statements is true regarding plastics processing?
- Unlike metals, plastics must be processed without the addition of heat.
 - Both thermoplastics and thermosetting plastics may be processed by molding, casting, and extrusion.
 - All plastics molding processes use liquid-state materials introduced into the mold cavity.
 - Injection molding can be done only with thermosetting materials.
- 15-2 Reinforced plastics molding involves use of:
- thermosetting plastics and fibrous reinforcement materials.
 - thermosetting plastics and metallic powder reinforcement.
 - thermoplastics and wood fiber reinforcement materials.
 - thermoplastics and metallic powder reinforcement.
- 15-3 The mechanism of adhesion combines mechanical interlocking and:
- stickiness of the adhesive.
 - roughness of the adherends.
 - dynamic mechanical forces.
 - interatomic forces.
 - all of the above.
- 15-4 Which of the following statements is true concerning composite materials?
- Composite materials include combinations of nonmetallic materials only.
 - When composite materials are cured, the constituents lose their original identity and form chemical compounds with one another.
 - A unique feature of composite materials is that their tensile strength frequently exceeds the strength of the strongest constituent.
 - Composites are usually formed into complex three-dimensional shapes with each dimension approximately equal to the other two.
 - None of the above statements are true.
- 15-5 Which of the following statements is true concerning honeycomb?
- Nonmetallic honeycomb derives high strength and rigidity from a structural combination of relatively weak, thin, lightweight materials.
 - In honeycomb, the walls of the cellular core material are aligned parallel with the plane of the face sheets.
 - All-metallic honeycomb can be bonded by adhesives, brazing, or diffusion welding, but honeycomb containing nonmetallic elements can be bonded only by adhesives.
 - Both a and b are true.
 - Both a and c are true.

- 15-6 The major difference between materials classified as composites and those classified as mixtures is that:
- mixtures are a type of composite with random orientation and shape of the constituents.
 - composites contain metallic constituents and mixtures are nonmetallic.
 - mixtures start as liquids blended together and composites start as solids.
 - mixtures are elastomeric, while composites are characterized as having at least one plastic component.
- 15-7 The acronym EDM refers to:
- engineering design materials.
 - energy discharge machines.
 - electro-dynamic machining.
 - electrical discharge machining.
 - elastomeric/diatomic mixture.
- 15-9 The process used for shaping metals by chemical dissolution only, with selective removal accomplished by masking areas where metal is not to be removed, is called:
- electrical discharge machining.
 - chemical milling.
 - electrochemical machining.
 - electroforming.
 - none of the above.

Figure 7.10

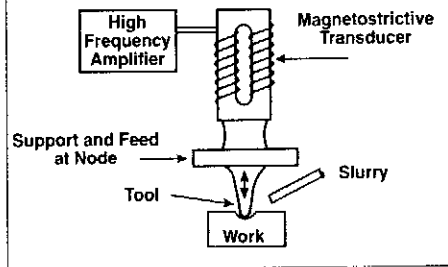
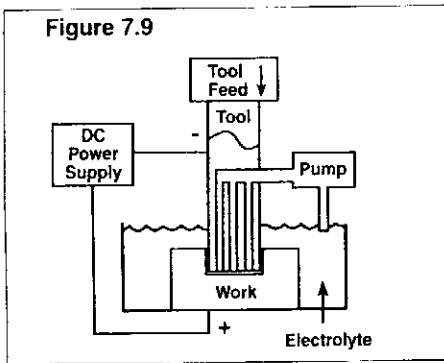


Figure 7.9



- 15-10 The process illustrated in Figure 7.10 is called:
- electrical discharge machining.
 - ultrasonic machining.
 - chemical milling.
 - electrochemical machining.
 - abrasive drilling.
- 15-11 A process that is the reverse of electrochemical machining and that is the basis for electroplating is called:
- chemical milling.
 - electrical discharge machining.
 - electroforming.
 - magnetoforming.

- 15-8 Figure 7.9 illustrates:
- chemical milling.
 - electrochemical machining.
 - ultrasonic machining.
 - vapor honing.
 - electrolytic grinding.

- 15-12 A cutting operation that has the ability to cut through thicknesses of over 0.9 m (3 ft) of steel and is commonly used to remove surface defects on castings and forgings by "scarfing" is called:
- friction cutting.
 - oxyacetylene cutting.
 - ultrasonic cutting.
 - gas metal arc cutting.
 - plasma arc cutting.
- 16-4 Coatings are often applied to protect a material; their thickness can frequently be determined nondestructively by:
- acoustic emission.
 - eddy current.
 - surface wave ultrasonic techniques.
 - optical holography.
- 16-5 The best and most economical cleaners used for removal of oils and greases are:

Chapter 16, Surface Finishing

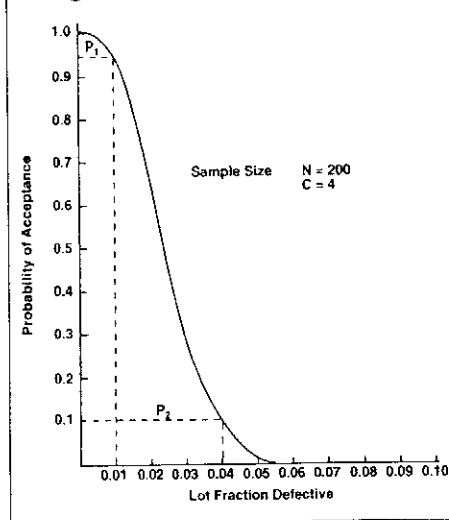
- 16-1 Which of the following statements is not true concerning surface finishing?
- Cleaning operations are considered to be surface finishing processes.
 - Surface finishing is often performed for corrosion protection.
 - Surface finishing is not typically followed by further processes.
 - Surface finishing is sometimes performed to improve surface and near-surface mechanical properties.
- 16-2 Carburizing and flame hardening are examples of:
- annealing processes.
 - casehardening processes.
 - processes that produce ductile surfaces.
 - electrochemical processes.
- 16-3 Which of the following nondestructive tests would provide the best results in measuring the case depth on a case hardened part?
- Ultrasonic immersion testing using a very low frequency probe.
 - Radiography.
 - Eddy current.
 - Magnetic particle.
 - All of the above could provide case depth measurements.
- 16-6 Some materials, such as aluminum, are corrosion resistant:
- by virtue of the immediate oxidation of newly exposed surfaces.
 - only if anodized.
 - because the material itself will not readily combine with oxygen.
 - against all types of corrosive atmospheres.
- 16-7 An advantage of electrostatic spraying is that:
- the material being sprayed is directly attracted to all of the surfaces to be covered.
 - there is less waste due to over-sprayed material.
 - there is more uniform coverage of the surfaces.
 - both a and c.
 - all of the above.
- 16-8 A corrosion protection material commonly applied to steel by hot dipping and galvanizing is:
- porcelain.
 - copper.
 - paint.
 - zinc.
 - chromic acid.

- 16-9 Metals commonly applied to other metals by electroplating are:
- nickel, chromium, and cadmium.
 - tin, zinc, and tungsten.
 - silver, gold, and carbon.
 - copper, aluminum, and magnesium.
 - both a and d.
- 16-10 A process that converts the base metal surface to an oxidized barrier layer of very small porous cells is called:
- galvanizing.
 - plating.
 - anodizing.
 - metallizing.
- 16-11 The anodized surface on aluminum:
- can produce a high background during a penetrant test.
 - is very dense and makes X-ray penetration difficult.
 - can produce cracks that are easily detected by eddy current testing techniques.
 - must be removed before performing ultrasonic tests.
 - can apply to all of the above.

Chapter 17, Inspection

- 17-1 A technique for the inspection of manufactured products that utilizes the selection of a certain percentage of parts for inspection is called:
- standard deviation.
 - random sampling.
 - consumer risk curve.
 - natural selection.
 - analysis of variance.
- 17-2 Implied in sampling inspection is:
- that the chosen plan will produce precise numbers of acceptable parts.
 - the need for a sample size of 100 units or multiples thereof.
 - a willingness to sometimes accept defective products.
 - the need to collect data in the form of variables instead of attributes.

Figure 7.11



- 17-3 On the operating characteristic curve shown in Figure 7.11:
- the line P_2 indicates that in the given sample, four parts were found to be defective.
 - the line P_1 indicates that if the lot being inspected had 1% defectives, there is a 6% probability that this plan would reject the lot.
 - the lot fraction defective cannot exceed 6%.
 - there is a 10% probability of accepting a 1% defective lot.
- 17-4 A process control chart based on the means and ranges of measurements taken on periodic samples requires the measurement to be taken of:
- attributes.
 - variables.
 - either attributes or variables.
 - neither attributes nor variables.

- 17-5 Frequently, dimensions are permitted to vary within specified limits. These variations are called:
- variances.
 - fudge factors.
 - absolute dimensions.
 - factors of safety.
 - tolerances.
- 17-6 Measurements are classified as being either:
- comparative or absolute.
 - comparative or dimensional.
 - general or specific.
 - dimensional or angular.
 - microscopic or macroscopic.
- 17-7 A vernier measurement permits:
- accurate interpolation between major divisions on a measuring device.
 - measurements to be accurate within 0.03 mm (0.001 in.).
 - extending the length of a measurement scale by ten times.
 - measurements to be traced to the National Bureau of Standards.
- 17-8 Indicating gages are usually used in applications that provide:
- absolute measurements.
 - comparative measurements.
 - long linear measurements.
 - reflected or projected images of the workpiece.
- 17-9 Which of the following measurement tools uses the principle of light wave interference to check surface flatness?
- Optical comparator.
 - Vernier caliper.
 - Sine bar.
 - Go/no go gage.
 - None of the above.
- 17-10 Gages such as plug gages, ring gages, go/no go gages, profile gages, thread gages, radius gages, etc., are all types of:
- variable measurement tools.
 - absolute gages.
 - optical gages.
 - fixed gages.
- 17-11 Devices that show magnified reflected or profile images of the work piece on a frosted glass screen are called:
- optical comparators.
 - optical flats.
 - optical projectors.
 - optical micrometers.
 - optical gages.

Answers to Review Questions

Answers to Section I

Q.1-1	d
Q.1-2	a
Q.1-3	b
Q.1-4	d
Q.1-5	b
Q.1-6	c
Q.1-7	d
Q.1-8	b
Q.1-9	e
Q.1-10	a
Q.1-11	c
Q.1-12	b
Q.1-13	c
Q.1-14	c
Q.1-15	d
Q.1-16	a
Q.1-17	b
Q.1-18	d
Q.1-19	a
Q.1-20	a
Q.1-21	c
Q.1-22	e
Q.1-23	d
Q.1-24	b
Q.1-25	c
Q.1-26	a
Q.1-27	d
Q.1-28	c
Q.1-29	a
Q.1-30	a
Q.1-31	b
Q.1-32	c
Q.1-33	d
Q.1-34	a
Q.1-35	d
Q.1-36	d
Q.1-37	c
Q.1-38	b
Q.1-39	c
Q.1-40	d
Q.1-41	e
Q.1-42	d
Q.1-43	c
Q.1-44	a
Q.1-45	c
Q.1-46	a
Q.1-47	b
Q.1-48	d
Q.1-49	d
Q.1-50	b
Q.1-51	c
Q.1-52	d
Q.1-53	a
Q.1-54	b
Q.1-55	b
Q.1-56	c
Q.1-57	d
Q.1-58	c
Q.1-59	a
Q.1-60	a
Q.1-61	b
Q.1-62	d
Q.1-63	b
Q.1-64	d
Q.1-65	d
Q.1-66	d
Q.1-67	a
Q.1-68	c
Q.1-69	d
Q.1-70	d
Q.1-71	c
Q.1-72	b
Q.1-73	a
Q.1-74	e

Answers to Section II

AE-1	b	IR-1	b
AE-2	d	IR-2	a
AE-3	d	IR-3	d
AE-4	c	IR-4	c
AE-5	a	IR-5	d
AE-6	c	IR-6	a
AE-7	a	IR-7	c
AE-8	b	IR-8	b
AE-9	d	IR-9	d
AE-10	a	IR-10	c
		IR-11	b
ET-1	c	IR-12	b
ET-2	a	IR-13	a
ET-3	b	IR-14	a
ET-4	c	IR-15	c
ET-5	a	IR-16	b
ET-6	a	IR-17	a
ET-7	d	IR-18	b
ET-8	c	IR-19	d
ET-9	c	IR-20	b
ET-10	d	IR-21	a
ET-11	d	IR-22	b
ET-12	b		
ET-13	c	LT-1	d
ET-14	b	LT-2	d
ET-15	a	LT-3	d
ET-16	e	LT-4	c
ET-17	c	LT-5	c
ET-18	b	LT-6	c
ET-19	a	LT-7	a
ET-20	d	LT-8	c
ET-21	d	LT-9	b
ET-22	b	LT-10	c
ET-23	a		
ET-24	a	MT-1	c
ET-25	b	MT-2	c
ET-26	a	MT-3	b
ET-27	a	MT-4	c
		MT-5	b
		MT-6	b
		MT-7	e

MT-8	b	PT-8	a	UT-1	e	VT-18	a
MT-9	a	PT-9	d	UT-2	d	VT-19	d
MT-10	c	PT-10	b	UT-3	d		
MT-11	b	PT-11	c	UT-4	c		
MT-12	c	PT-12	b	UT-5	b	Answers to	
MT-13	c	PT-13	a	UT-6	d	Section III	
MT-14	d	PT-14	c	UT-7	a	1-1	c
MT-15	b	PT-15	b	UT-8	b	1-2	a
MT-16	c	PT-16	b	UT-9	b	1-3	a
MT-17	d	PT-17	a	UT-10	b	1-4	d
MT-18	c	PT-18	a	UT-11	c	1-5	d
MT-19	b	PT-19	c	UT-12	c	1-6	b
MT-20	b	PT-20	b	UT-13	d	1-7	b
MT-21	b	PT-21	e	UT-14	b		
MT-22	d	PT-22	c	UT-15	d	2-1	e
NR-1	c	PT-23	b	UT-16	d	2-2	b
NR-2	d	PT-24	c	UT-17	a	2-3	d
NR-3	d	PT-25	e	UT-18	b		
NR-4	d			UT-19	d	3-1	d
NR-5	d	RT-1	a	UT-20	d	3-2	b
NR-6	a	RT-2	d	UT-21	a	3-3	c
NR-7	b	RT-3	c	UT-22	c	3-4	d
NR-8	d	RT-4	b	UT-23	e	3-5	b
NR-9	c	RT-5	b	UT-24	b	3-6	d
NR-10	c	RT-6	d	UT-25	b	3-7	d
NR-11	c	RT-7	c	UT-26	c	3-8	d
NR-12	c	RT-8	c	UT-27	d	3-9	c
NR-13	e	RT-9	a	UT-28	a	3-10	b
NR-14	b	RT-10	d	UT-29	e	3-11	b
NR-15	c	RT-11	c	UT-30	b	3-12	b
NR-16	b	RT-12	c	UT-31	e	3-13	b
NR-17	b	RT-13	b	UT-32	e	3-14	e
NR-18	a	RT-14	a				
NR-19	a	RT-15	c	VT-1	b	4-1	c
NR-20	b	RT-16	b	VT-2	d	4-2	c
NR-21	a	RT-17	d	VT-3	a	4-3	c
NR-22	b	RT-18	d	VT-4	b	4-4	b
NR-23	b	RT-19	d	VT-5	c	4-5	c
NR-24	b	RT-20	b	VT-6	a	4-6	d
NR-25	c	RT-21	b	VT-7	c	4-7	b
NR-26	d	RT-22	c	VT-8	c	4-8	a
NR-27	d	RT-23	a	VT-9	b	4-9	c
		RT-24	c	VT-10	d	4-10	a
PT-1	b	RT-25	d	VT-11	b	4-11	d
PT-2	d	RT-26	c	VT-12	d	4-12	e
PT-3	a	RT-27	d	VT-13	b	4-13	b
PT-4	e	RT-28	b	VT-14	d	4-14	d
PT-5	d	RT-29	e	VT-15	b	4-15	e
PT-6	b	RT-30	c	VT-16	a	4-16	d
PT-7	b			VT-17	d		

5-1	a	8-12	c	10-19	e	14-4	d
5-2	b	8-13	c	10-20	b	15-1	b
5-3	c	8-14	b	10-21	b	15-2	a
5-4	a	8-15	c	10-22	e	15-3	d
5-5	d	8-16	a			15-4	e
5-6	e	8-17	d	11-1	a	15-5	e
5-7	d	8-18	b	11-2	e	15-6	a
5-8	c			11-3	c	15-7	d
5-9	b	9-1	d	11-4	d	15-8	b
5-10	c	9-2	c	11-5	b	15-9	b
5-11	c	9-3	d	11-6	c	15-10	b
5-12	b	9-4	b	11-7	b	15-11	c
6-1	d	9-5	a	11-8	d	15-12	b
6-2	e	9-6	d	11-9	b		
6-3	b	9-7	b			16-1	c
6-4	c	9-8	b	12-1	a	16-2	b
6-5	a	9-9	a	12-2	b	16-3	c
6-6	b	9-10	c	12-3	b	16-4	b
6-7	a	9-11	d	12-4	d	16-5	d
6-8	e	9-12	d	12-5	a	16-6	a
6-9	c			12-6	b	16-7	e
6-10	d	10-1	c	12-7	c	16-8	d
6-11	b	10-2	a	12-8	c	16-9	a
		10-3	d	12-9	d	16-10	c
7-1	d	10-4	d	12-10	d	16-11	a
7-2	a	10-5	a	12-11	b		
7-3	e	10-6	b	12-12	c	17-1	b
		10-7	d	12-13	a	17-2	c
8-1	b	10-8	b	12-14	d	17-3	b
8-2	c	10-9	b	12-15	e	17-4	b
8-3	d	10-10	a			17-5	e
8-4	c	10-11	c	13-1	e	17-6	a
8-5	d	10-12	d	13-2	a	17-7	a
8-6	b	10-13	c	13-3	a	17-8	b
8-7	d	10-14	a	13-4	c	17-9	e
8-8	e	10-15	e			17-10	d
8-9	a	10-16	a	14-1	c	17-11	a
8-10	c	10-17	b	14-2	b		
8-11	c	10-18	b	14-3	c		

Appendix 1

Code of Ethics for Level III NDT Personnel Certified by ASNT

1. Preamble

1.1 In order to safeguard the life, health, property and welfare of the public, to maintain integrity and high standards of skills and practices in the profession of nondestructive testing, the following rules of professional conduct shall be binding upon every person issued a certificate by ASNT as an NDT Level III.

1.1.1 The NDT Level III who holds a certificate from ASNT is charged with having knowledge of the existence of the reasonable rules and regulations hereinafter provided for his/her conduct as NDT Level III, and also shall be familiar with their provisions and understand them. Such knowledge shall encompass the understanding that the practice of nondestructive testing under this certification is a privilege, as opposed to a right, and the NDT Level III shall be forthright and candid in statements or written responses to the Ethics Committee of the National Certification Board.

1.1.2 The "NDT Level III" as referred to herein, is that individual who has been issued a certificate by The American Society for Nondestructive Testing, Inc. pursuant to its heretofore published requirements, rules and procedures for such certification. This Code of Ethics is binding upon all individuals so certified.

2. Integrity

2.1 The NDT Level III is obligated to act with complete integrity in professional matters for each client or employer as a faithful agent or trustee; shall be honest and impartial, and shall serve the public, clients and employer with devotion.

3. Responsibility to the Public

The NDT Level III shall:

3.1 Protect the safety, health and welfare of the public in the performance of professional duties. Should the case arise where the NDT Level III faces a situation where the safety, health and welfare of the public are not protected, he/she shall:

3.1.1 Apprise the proper authority if it is evident that the safety, health and welfare of the public are not being protected; and

3.1.2 Refuse to accept responsibility for the design, report or statement involved; and

3.1.3 If necessary, sever relationship with the employer or client; and

3.1.4 Undertake to perform assignments only when qualified by training and experience in the specific technical fields involved. In the event a question arises as to the competence of an NDT Level III to perform an assignment in a field of specific discipline which can not be otherwise resolved to the Ethics Committee's satisfaction, the Ethics Committee, either upon request of the NDT Level III or by its own volition, may require him/her to submit to an appropriate inquiry by or on behalf of the Ethics Committee; and

3.1.5 Be completely objective in any professional report, statement or testimony. He/She shall include all relevant and pertinent information in the report, statement or testimony avoiding any omission which would, or reasonably could, lead to a fallacious inference, finding or misrepresentation; and

3.1.6 Express an opinion as a technical witness before any court, commission or other tribunal, only

when such opinion is founded upon adequate knowledge of the facts in issue, upon a background of technical competence in the subject matter, and upon honest conviction of the accuracy and propriety of the testimony.

4. Public Statements

- 4.1 The NDT Level III will issue no statements, criticisms or arguments on nondestructive testing matters connected with public policy which are inspired or paid for by an interested party, or parties unless he/she has prefaced the remark(s) by explicitly identifying him/herself, by disclosing the identities of the party, or parties, on whose behalf he/she is speaking, and by revealing the existence of any pecuniary interest he/she may have in these matters.
- 4.2 The NDT Level III will publicly express no opinion on a nondestructive testing matter unless it is founded upon adequate knowledge of the facts in issue, upon a background of technical competence in the subject matter, and upon honest conviction of the accuracy and propriety of the testimony.
5. Conflict of Interest
- 5.1 The NDT Level III shall conscientiously avoid conflict of interest with the employer, or client, but when unavoidable, shall forthwith disclose the circumstances to the employer or client.
- 5.2 The NDT Level III shall promptly inform the client or employer of any business associations, interests, or circumstances which could influence his/her judgment or the quality of services to the client or employer.
- 5.3 The NDT Level III shall not accept compensation, financial or otherwise, from more than one party for services on the same project, or for services pertaining to the same project, unless the circumstances are fully disclosed to, and agreed to, by all interested parties or their duly authorized agents.
- 5.4 The NDT Level III shall not solicit or accept financial or other valuable considerations from material or equipment suppliers for specifying their products.

5.5 The NDT Level III shall not solicit or accept gratuities, directly or indirectly, from contractors, their agents or other parties dealing with the client or employer in connection with work for which he/she is responsible.

5.6 As an elected, retained or employed public official, the NDT Level III (in the capacity as a public official) shall not review or approve work that was performed by him/herself, or under his/her direction, on behalf of another employer or client.

6. Solicitation of Employment

- 6.1 The NDT Level III shall not pay, solicit, nor offer, directly or indirectly, any bribe or commission for professional employment with the exception of payment of the usual commission for securing salaried positions through licensed employment agencies.
- 6.2 The NDT Level III shall seek professional employment on the basis of qualification and competence for proper accomplishment of work.
- 6.3 The NDT Level III shall not falsify or permit misrepresentation of his/her, or his/her associates', academic or professional qualification. He/She shall not misrepresent or exaggerate the degree of responsibility in or for the subject matter of prior assignments.
- 6.4 Brochures or other presentations, incident to the solicitation of employment shall not misrepresent pertinent facts concerning employers, employees, associates, joint venturers, or their past accomplishments with the intent and purpose of enhancing qualifications and work.
7. Improper Conduct
- 7.1 The NDT Level III shall not sign documents for work for which he/she does not have personal professional knowledge and direct technical supervisory control and responsibility.
- 7.2 The NDT Level III shall not knowingly associate with, or permit the use of his/her name or firm name in a business venture by any person or firm which he/she knows, or has reason to believe is engaging in business or professional practices of a fraudulent or dishonest nature.

8. Unauthorized Practice

- 8.1 Any violation of this Code shall be deemed to be an unauthorized practice and upon proper complaint, investigation, due process hearing and ruling of the Ethics Committee of the National Certification Board in accordance with procedures heretofore established and published, sanctions may be applied to the individual(s) in violation.

9. Rulings of Other Jurisdictions

- 9.1 Conviction of a felony while ASNT certification is valid, or the revocation or suspension of a Professional Engineer's License by another jurisdiction, or similar rulings by other professional associations, may be grounds for a charge of violation of this Code.

Index

- Acceptance standards, 21, 34
- Acid baths, 110
- Acoustic emission testing, 7, 16, 46, 59-60, 98
- Adhesion, 113
- Aircraft, 89, 101
- Aircraft skin inspection, 89
- Alloy(s), 64, 71, 95, 100-101
- Alternating current, 62, 73-74, 100
- Aluminum alloy, 71, 100
- Amperage, 73
- Angle-beam, 83-85
- Annealing, 98, 115
- Anodized surface(s), 71, 116
- Anodizing process, 71
- Area-amplitude, 83
- ASM International, 57
- ASME, 18, 20, 35, 40, 49
- ASME Boiler and Pressure Vessel Code, 18, 35, 40, 49
- ASNT-CP-189 (1995)
 - Basic Examination coverage, 7, 11, 45-46, 54
 - certification to, 11, 51-56
 - consensus process, 51
 - employer's NDT Level III, 52, 54
 - similarities with *SNT-TC-1A*, 51-55
- Attenuation, 59-60, 81-83
- Audit, 37-38, 48
- Austenitic stainless steels, 100

- Back reflection, 83-84
- Back surface, 83-84
- Background, 69
- Background noise, 60
- Band pass filters, 60
- Base metal, 100, 104-108, 116
- Beam spread, 83
- Beryllium, 101
- Bessemer converter, 99
- Bessemer furnace, 99
- Betatrons, 78
- Billets, 110
- Body-centered cubic, 97
- Bond evaluation, 82
- Brass, 101
- Brazing, 104, 110, 113
- Bronze, 101
- Bubble leak detection, 67
- Bubble leak testing, 25-26, 67
- Butt joint, 107
- Buttress groove, 107
- Buyer-seller, 16-17, 47-48

- Camera, 87
- Carburizing, 115
- Case depth, 115
- Cassette, 76, 80
- Cast iron, 96, 109
- Cast steel, 100
- Castings, 60, 68, 71, 77-78, 85, 99, 103-104, 111, 115
- Ceramics, 60, 103
- Certification (*ASNT CP-189 (1995)*)
 - record of, 54
 - reinstatement of, 54-55
 - renewal of, 54
 - requirements of, 17, 51-53
 - revocation of, 54-55
 - suspension of, 54
- Certification (*SNT-TC-1A*)
 - administration of certification examinations, 31, 35-36, 38, 41, 45-46
 - continuing satisfactory performance, 37, 41
 - criteria for, 7-8, 17, 24, 34
 - definition of, 15, 18, 20
 - examinations, 7, 13-15, 31, 38-39, 45-46, 48-49
 - extension of, 37
 - expiration of, 47
 - guidelines for, 15-16, 21
 - of NDT personnel, 11, 13, 14, 16-17, 23, 37-39, 42, 47-49
 - options, 40, 47-48
 - Level I, 21, 27
 - Level II, 24-26, 34
 - Level III, 21, 24, 34, 37-40, 42, 45-49
 - period, 45, 47
 - prior evidence of, 24, 38, 41
 - program, 7, 11, 15, 18, 24, 28, 31, 42, 45, 47-49
 - recommendations, 14, 17, 19, 22-23, 36, 43, 47
 - renewal of, 45, 49
 - requirements for, 11, 13, 17-18, 23-24, 28, 39
 - responsibilities, 47
 - revocation of, 37, 40-42, 125
 - suspension of, 125
 - termination of, see *revocation of*
 - transfer of, 43
 - verification of, 13, 34, 55
- Cf-252, 77
- Chemical dissolution, 114
- Chemical processing industry, 101
- Chromium, 100, 116
- Circular magnetization, 72
- Circulating electrical current(s), 61
- Cleaning, 70, 107, 110, 115

- Close adherence, 14
- Close-packed hexagonal, 97
- Co-60, 75, 78, 81
- Coarse-grained materials, 82
- Coatings, 63, 105, 115
- Cobalt, 78
- Codes, 18, 20, 23, 28, 32-34, 46-48, 54, 59, 87
- Coke, 99
- Cold shut, see *Discontinuities*
- Cold finishing operations, 110
- Cold rolling, 111
- Cold working operations, 110
- Color contrast, 32, 89
- Columbium, 76
- Combustion, 99
- Composite materials, 95, 113
- Compounds, 97, 113
- Compressional waves, 82
- Compressive strength, 96, 110
- Conductive heat transfer, 64
- Conductive material(s), 61-63
- Conductivity, 61, 85, 98, 100
- Contact temperature indications, 64
- Contact testing, 84
- Contractors, 13, 19, 124
- Contracts, 15
- Conversion layer, 71
- Cooling crack, see *Discontinuities*
- Copper slides, 106
- Core shift, see *Discontinuities*
- Corrosion, 71, 74, 89, 95, 98-100, 105, 109, 111, 115
- Corrosion detection, 74
- Corrosion resistance, 95, 99, 100-101, 115
- Counts, 60
- Coupling, 61-62, 81, 84
- CP-189 (1995), see *ASNT-CP-189 (1995)*
- Crack(s), see *Discontinuities*
- Crater cracks, see *Discontinuities*
- Creep, see *Discontinuities*
- Cs-137, 75
- Curriculum, evaluation of, 28
- Customer(s), 13-14, 17

- Data filtering techniques, 59
- Deep drawing, 112
- Deformation, 60, 94-95, 97-98, 102, 109, 111
- Degreasing, 110
- Demagnetization, 71-73
- Descaling, 110
- Design engineer(s), 101
- Design stress, 97
- Developers, 69-71
- Die casting, 100, 103, 110
- Diffuse reflecting surface, 65
- Diffuse reflection, 88
- Diffusion welding, 106, 113
- Digital thickness measurement equipment, 17, 20, 22
- Direct hardness tests, 97

- Discontinuities
 - cold shut, 70
 - cooling crack, 105
 - core shift, 103
 - crack(s), 70, 74, 77, 88, 105, 107-108
 - crater cracks, 107
 - creep, 89, 96-97
 - draw marks, 89
 - fatigue, 96, 109
 - fatigue cracks, 74
 - forging lap, 70
 - inclusions, 63, 85, 109
 - lack of parallelism, 84
 - laminar discontinuities, 81, 85
 - nonfused chaplets, 103
 - porosity, 70, 85, 102, 104-105, 108-109, 111
 - reflection indications, 85
 - round indications, 70
 - shrinkage, 81, 102-105, 109
 - shrinkage cavities, 103, 109
 - slag inclusion, 107
 - undercut, 107
- Distance-amplitude calibration, 83
- Draw marks, see *Discontinuities*
- Drawing, 104, 110-112
- Ductile materials, 110
- Dysprosium, 75

- Echoes, detection of, 83
- Eddy current generation, 60
- Eddy current penetration, 62
- Eddy current sensors, 60
- Eddy current testing, see *Electromagnetic testing*
- Educational accomplishments, 15, 31, 34, 37
- Educational degree, 24, 32, 45
- Elastic limit, 97-98
- Electric current, 71
- Electric arc, 105
- Electric conductors, 79
- Electrical, 60-61, 64, 67, 79, 85, 98, 100, 112, 114
- Electrical conductivity, 85, 98, 100
- Electricity, 71
- Electrochemical machining, 114
- Electrode, 105-107
- Electrolysis, 98
- Electromagnetic radiation, 78
- Electromagnetic testing, 7, 16, 46, 60-64
- Electrostatic spraying, 115
- Electronic technique, 59
- Electroplating, 99, 114, 116
- Electrostatic spray, 115
- Emissivity, 65
- Employer programs, acceptability of, 15
- Employer-based certification/examination, 48, 54
- Employer's representative, 31, 54-55
- Employment, termination of, 40-41, 54
- Encircling coil, 63
- Endothermic investigations, 64
- Engineer, 23, 125

- Engineering, 24-25, 45, 93
- Establish techniques, 20, 23, 59
- Evacuated systems, 67
- Examinations
 - Basic Examination, 7, 11, 20, 33, 45-49, 54, 59, 93
 - composite grades, 31-32, 36, 37, 48
 - evaluation of, 34, 47, 48, 54, 59
 - closed book, 15, 33, 36, 53
 - conductance of, 35, 39, 55
 - grade(s), 13-14, 24, 31-32, 34-35, 37, 45, 55
 - mandatory Basic Examination, 45
 - Method Examination, 7, 33, 36, 46-49, 54
 - modification of examination questions, 17
 - multiple-choice questions, 7, 46, 54
 - passing grades, 24, 31-32, 45, 52
 - qualification for, 7
 - reporting of grades, 32, 48
 - request for examination, 46, 123
 - self-examination, 54
 - Specific Examination, 14, 32-36, 47-48, 53-54
 - unsupervised, 38
 - waiver of, 39
- Excess penetrant removal, 69
- Exothermic investigations, 64
- Explosive and pyrotechnic devices, 74
- Extrusions, 87, 89, 104, 111
- Eye adaptation, 88

- J fabrication, 20, 33, 46, 59, 73
- Face-centered, cubic, 97
- Failure(s), 18, 94, 96, 102
- Fast-neutron radiography, 75
- Fatigue, *see Discontinuities*
- Fatigue cracks, *see Discontinuities*
- Fatigue resistance, 109
- Feeders, 103
- Felicity effect, 60
- Felony conviction, 125
- Field inspections, 68, 71, 78, 86
- Film density, 80
- Film resolutions, 76
- Flame hardening, 115
- Flat probe coil, 62
- Flat-bottomed holes, 83
- Flaw detection, 61, 82
- Flaws, 77, 85, 94-95
- Fluid flow investigations, 64
- Fluorescence, 68-69, 88
- Fluorescent penetrant, 69
- Fluorescent magnetic particles, 73
- Fluoroscopic image, 79
- Fluoroscopy, 81
- Forging(s), 70, 87, 93, 110, 115
- Forging lap, *see Discontinuities*
- Forming, 110-112
- Fracture, 94-95
- Fracture control, 94
- Frequency, 60, 62, 82, 86
- Friction investigations, 64
- Fusion bonding, 104
- Fusion welds, 105
- Fusion zone, 84

- Gadolinium, 75-76
- Gadolinium screens, 75
- Gages, 117
- Galvanizing, 110, 115-116
- Gamma radiation, 77-78
- Gamma rays, 78-79
- Gate, 102-103
- Geometric distortion, 105, 108
- Gold, 75, 116
- Grain size, 104
- Grain size variation, 104
- Grain structure, 85
- Grammar school, 25
- Graybody, 65
- Green sand casting molds, 103

- Halogen diode detector, 67-68
- Halogen diode leak detection, 25-26
- HAZ, *see heat affected zone*
- Heat affected zone, 89
- Heat flux indicators, 64
- Heat transfer, 64, 106
- Heat treatment, 98, 100, 105, 108
- Helium mass spectrometer, 67
- Hermetic seals, 67
- High frequency variable, 64
- High voltage radiography, 80
- High school, 29, 52
- Honeycomb, 77, 113

- IACS, 61
- IES, *see Illuminating Engineering Society*
- Illuminating Engineering Society, 88
- Illumination angle, 88
- Image, 76-77, 79-81, 89
- Imagers, 66
- Imaging, 64, 74-75, 77
- Impedance, 62, 64
- Inclusions, *see Discontinuities*
- Inconel, 80, 101
- Indication(s), 51, 69-70, 73-74, 83
- Image quality indicators, 77, 81
- Indirect radiography, 75
- Indium, 75
- Industrial, 46, 93
- Inert gas, 106
- Infrared energy, 65
- Infrared focal plane array imagers, 66
- Infrared radiation, 65
- Infrared spectral filter, 66
- Infrared spectrum, 65
- Infrared/Thermal testing, 7, 16, 46, 53, 64-66
- Infrared thermal detectors, 65
- Inquiries, *see Recommended Practice No. SNT-TC-1A*
 - inquiries and responses

- Inspection of castings, 85, 103
- Interaction of penetrants, 68
- Interpretation Panel, 11, 15-16, 18-19, 21, 24
- Interpretations, see *Recommended Practice No. SNT-TC-1A inquiries and responses*
- IQI, see *Image quality indicator*
- Iron, 77, 95-97, 99-101, 109-110
- Iron-based alloys, 95
- Isotopic, 74, 76-77

- Jaeger No. 1, 53
- Jaeger No. 2, 32, 53
- Jaeger letters, 35, 56

- Kaiser effect, 60

- Lack of parallelism, see *Discontinuities*
- Laminar discontinuities, see *Discontinuities*
- Laminate, 85
- Lead, 76, 80
- Lead foil, 80
- Leak detection, 68, 71
- Leak testing, 7, 16, 30-31, 46, 67-68
- Level I
 - duties, 20-21, 54
 - record results, 20
- Level II
 - duties, 54
 - inspector, 45
 - interpretation of NDT results, 54
 - report results of NDT tests, 20
- Level III
 - administration of NDT programs, 42
 - compensation for services, 124
 - competence of, 123
 - complaints against, 125
 - conflict of interest, 124
 - control of NDT personnel, 23, 124
 - duties, 53, 123
 - establish acceptance criteria, 20, 59
 - falsification of qualifications, 124
 - interpretation of codes, 20, 33, 46, 59
 - NDT operations, 20, 59
 - objectivity of, 123
 - obligations of, 57
 - qualified representative for, 31, 54-55
 - recommendation of new techniques, 59
 - rules of professional conduct for, 123
 - unauthorized practice of, 125
- Light emission, 75
- Lighting conditions (minimum), 88
- Limestone, 99
- Light wave interference, 117
- Line scanner(s), 64, 66
- Liquid penetrant testing, 7, 16-17, 42, 46, 68-71, 73
- Longitudinal waves, 82-84
- Lost wax process, 103

- Machinability, 109, 112
- Machine tools, 112
- Machined parts, 68, 71
- Machining, 112, 114
- Magnet, 72
- Magnetic fields, 72
- Magnetizing flux, 72
- Magnetic lines of force, 72
- Magnetic particle testing, 7, 16, 27, 42, 46, 71-74
- Magnetic particles, 73
- Magnetization, 71-72
- Magnified reflected images, 117
- Magnetizing flux, 72
- Magnetizing current, 72, 74
- Manufactured products, 116
- Manufacturer, 13, 17, 29
- Manufacturing, 46, 94-95, 101-102
- Marine industry, 101
- Masking, 114
- Mass spectrometer, 25-26, 67
- Materials, acceptability of, 23, 59
- Materials and processing, 93
- Mechanical interlocking, 113
- Metal flow, 103
- Metals processing, 111
- Method Examination, see *Examinations*
- Microcircuits, 87
- Mixtures, 114
- Modulus of elasticity, 96
- Mold, 102-104, 106, 113
- Monel, 101

- Nature of penetrating radiation, 74, 77
- NDT instructor, 51-52, 56
- NDT personnel, examination of, 13-15, 18, 21, 23, 37-39, 45, 48
- NDT procedure, preparation of, 34, 47-48, 54
- NDT test data, 51
- NDT tests, conductance of, 20, 35, 39, 55
- NDT tests, evaluation of, 15-16, 19-22, 54
- Near-distance visual acuity, 32, 35, 56
- Near-vision acuity, 32
- Neutron radiographic testing, 7, 16, 46, 73-77, 79
- Neutrons, 74-79
- Nickel, 100
- Noise discrimination, 59
- Non-gray target, 66
- Non-imaging detectors, 74
- Nonconsumable electrode, 106
- Noncontact devices, 64
- Noncontact pyrometer, 64
- Nonferrous metals, 98, 100
- Nonfused chaplets, see *Discontinuities*
- Nonimaging detectors, 77
- Nonrelevant indications, 51, 70

- On-the-job training, 13, 20, 23
- Optical interference patterns, 89

- Ortho-rater, 32
Outgassing, 68
- Paramagnetic stainless steels, 100
Penetrameter(s), 80
Penetrants, 68-69, 71
Penetrating radiation, 74, 77-78
Permeability, 61
Personnel training, 13-14, 23-24, 37-38, 59
Phase discrimination, 60
Photographic plane, 87
Photon detectors, 65
Physical examination requirements, 35
Physics, 45, 52
Pig iron, 99
Pillowing, 89
Piping, 67, 89, 104
Plastic flow, 96, 98, 109, 111
Plastics processing, 112-113
Plug gages, 117
Plutonium, 77
Polymerization, 101
Porosity, see *Discontinuities*
Position paper, 46
Post-emulsified penetrant process, 70
Post-emulsifier, 69
Post-heat treatment, 108
Powder metallurgy, 110-111
Preheat treatment, 108
Precipitation hardening, 98
Pressure vessels, 67, 87
Pressurized systems, 67
Principle of light wave interference, 117
Probability of detection, 81, 95
Process control, 61, 82, 85, 116
Prod method, 72-73
Professional Engineer's License, revocation of, 125
Profile gages, 117
Propagating wave, 60
Pu-239, 75
Pulse-echo techniques, 17, 85
Purchaser, 15, 38
Pyrotechnic devices, 74
- Qualification and certification program
 establishment of, 15, 17, 28, 51
 guidelines for, 14-16, 38, 51
Qualify(ing), 7, 13, 15, 17-18, 20, 26, 28-29, 34, 38-39, 48, 52
Quartz crystal, 84
- Radioactive source, 75
Radiograph, 75, 79-80
Radiographic testing, 7, 16, 28, 42, 46, 74, 77-81
Radius gages, 117
Raw material, 102
Recertification, 21, 37, 40-41, 43, 46-47, 53, 55
Recertification intervals, 37
- Recommended Practice No. SNT-TC-1A*
 college requirements, 24-25, 45
 compliance with, 39, 47
 education, verification of, 7, 16, 38, 45
 experience and performance, verification of, 16, 38-39, 48
 experience, evaluation of, 18, 24, 38
 inquiries and responses
 76-1, 27
 76-2, 27
 76-3, 21
 76-4, 16
 76-5, 21
 77-1, 42
 77-10, 38
 77-12, 38
 77-3, 37
 77-4, 24, 38
 77-6, 43
 78-1, 34
 78-10, 41
 78-2, 21, 43
 78-3, 27
 78-4, 41
 78-7, 17
 78-9, 21
 79-1, 28
 79-13, 34
 79-14, 28
 79-15, 28
 79-2, 34
 80-14, 21
 80-2, 35
 80-3, 27
 80-4, 17
 80-6, 28
 80-8, 16-17
 80-9, 39
 89-4, 38-39
 90-2, 39
 90-4, 39
 92-2, 39
 96-3, 39
- Interrupted service of personnel, 37, 41
 mandatory requirements of, 17, 20
 modification of, 15-17
 previous experience, documentation of, 18, 24, 38
 qualification, verification of, 13-14, 30
 record keeping, 20, 23, 32, 55
 requirements of, 11, 13, 17-18, 24, 28
 similarities with *ASNT-CP-189 (1995)*, 51-55
 training record, 55
 training requirements, documentation of, 13, 15, 23
Recommended Training Course Outline(s), 17, 30-31, 52
Recrystallization, 98, 109
Reexamination, 34, 37, 40-41, 46, 54
Reference blocks, 83
Reflection, 81, 85, 88
Reflection indications, see *Discontinuities*

- Reflectivity, 65
 Refraction, 81
 Reinforced plastics, 113
 Rejection/acceptance criteria, 20
 Relevant indications, 51
 Removal of oils and greases, 115
 Requalification, 27
 Resonance, 81, 83, 85-86
 Resonance condition, 83
 Resource material, 59
 Responses, see *Recommended Practice No. SNT-TC-1A*
 inquiries and responses
 Ring gage, 117
 Risers, 103
 Rolled bar stock, 71
 Rough welds, 74
 Round indications, see *Discontinuities*

 Safety, 67, 74, 77, 87, 97, 99, 123
 Sampling inspection, 116
 Sandblasting, 70
 Scarfing, 115
 Scattering, 81
 Science, 23-24, 30, 45, 52
 Search unit, 83-85
 Shaw, Carl B., 13
 Shear waves, 82-84
 Shielding, 105-106
 Short course, 14
 Shrinkage, see *Discontinuities*
 Shrinkage cavities, see *Discontinuities*
 Signal amplitude, 60
 Signal conditioning, 59, 86
 Signal detection, 59
 Signal processing, 59
 Sintering, 110-111
 Slabs, 110
 Slag inclusion, see *Discontinuities*
SNT-TC-1A, see *Recommended Practice No. SNT-TC-1A*
SNT-TC-1A interpretations, see *Recommended Practice*
No. SNT-TC-1A inquiries and responses
 Soldering, 104, 106
 Solids, 97, 114
 Solution heat treatment, 98
 Solvent-removable penetrants, 17, 69
 Sound travel, 82
 Sound wave, 82
 Soundbeams, 81
 Source, 7, 30, 60, 71, 74-75, 77-80, 88
 Source-to-film distance, 79
 Specific Examination, see *Examinations*
 Specimen selection, 32
 Spectral band, 65-66
 Spectral filter, 66
 Spectral range, 87-88
 Spectral region, 66
 Spheroidizing, 98
 Spinning, 112
 Spot size, 65

 Stainless steel, 80, 100
 Standards Development Committee, 15
 Steel-making process, 99, 109
 Straight beam, 85
 Strengthening and hardening, 100
 Structures, 60, 95, 97, 105
 Subcontracting services, 37-38
 Submerged arc welding, 106
Supplements to Recommended Practice No. SNT-TC-1A,
 32, 42
 Supplier(s), 15, 18, 24
 Surface defect removal, 115
 Surface probe coil, 62

 Target surface, 64
 Technical school, 24, 45
 Tempering, 98, 105
 Tensile load, 95-96
 Tensile strength, 95
 Tensile stress, 95
 Tensile tests, 95
 Test results
 documentation of, 14, 54
 evaluation of, 34, 47-48, 54, 59
 interpretation of, 14, 36, 54, 59
 Test samples, 53-54, 116
 Test specimens, 32, 36, 54, 63, 71, 95
 Thermal capacitance, 64
 Thermal conductivity, 108
 Thermal diffusivity, 66
 Thermal imaging, 65
 Thermal neutron beam, 74-76
 Thermal radiation, 65
 Thermal resistance, 64
 Thermal resistance investigations, 64
 Thermal resolution, 65-66
 Thermogram, 66
 Thermosetting plastic, 103
 Thickness gaging, 61
 Thickness measurement, 17, 20, 22, 82, 84-85
 Thin, 70, 75, 77, 80, 85, 102, 109, 113
 Thread gages, 117
 Threshold settings, 60
 Tin, 101
 Tm-170, 78
 Tracer fluids, 67
 Tracer gas, 67
 Trainee(s), 20, 22, 52
 interpretation of NDT results, 20
 report results of NDT tests, 20
 Training course, 14, 17, 30-31
 Training program(s), 13-14, 16, 30-31, 52
 Transducers, 81, 83
 Transfer exposure method, 76
 Transfer method, 75
 Transfer radiography, 75
 Transmissivity, 65

- Ultrasonic beam, 82
- Ultrasonic immersion testing, 52, 82, 84
- Ultrasonic standard test blocks, 83
- Ultrasonic testing, 7, 16, 28, 42, 46, 52, 55, 81-86
- Ultrasonic velocities, 82
- Ultrasonic wave, 85
- Undercut, see *Discontinuities*
- University, 24, 45

- V-groove, 81, 108
- Vacuum chamber, 106
- Vector sum, 62
- Vernier measurements, 117
- Vibration and analysis testing, 7, 16, 46, 86-87
- Visible dye, solvent removable, 17, 69
- Visible light, 87
- Visible magnetic particles, 73
- Vision examinations, 32, 37, 53-55
- Visual acuity, 35, 56
- Visual and optical testing, 7, 16, 46, 87-89

- Warping, 108
- Water-washable penetrants, 69
- Wave travel, 81
- Wavelength of light, 69
- Weld bead, 74, 81, 85
- Weld joint, 107
- Weld zone, 105
- Weldment(s), 93, 105, 108
- Welds, 68, 71, 74, 78, 88-89, 104-105, 108-110

- Wet method, 73
- Witness of NDT, 15-16, 123
- Work hardening, 96
- Written practice
 - acceptance of ASNT Level III certification, 24
 - development of, 15-16, 18
 - establishment of, 13-8, 23, 39, 47
 - preparation of, 13, 15, 17, 21, 23-24, 27-29, 31-33, 35, 37-38, 41, 46
- Wrought metals, 68, 71, 109
- Wrought products, 109
- Wrought steels, 100

- X-radiation, 78
- X-radiography, 76
- X-ray absorption, 79
- X-ray beam, 78, 81
- X-ray exposure, 80
- X-ray film, 75, 80
- X-ray generators, 78
- X-ray machines, 78
- X-ray pattern, 81
- X-ray sources, 74, 77
- X-rays, 76, 79

- Yield strength, 96-97
- Young's Modulus, 79, 96

- Zinc, 100-101, 115-116