



AMERICAN SOCIETY
for
NONDESTRUCTIVE TESTING
Recommended Practice
No. SNT-TC-1A
(August 1984 Edition)

THIS DOCUMENT IS INTENDED AS A GUIDELINE FOR EMPLOYERS
TO ESTABLISH THEIR OWN WRITTEN PRACTICE FOR THE QUALI-
FICATION AND CERTIFICATION OF THEIR NDT PERSONNEL. IT IS
NOT INTENDED TO BE USED AS A STRICT SPECIFICATION.

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FOREWORD

The recommended practice contained herein 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 questions and answer lists which may be used in composing examinations for nondestructive testing personnel.

Inquiries related to this recommended practice should be directed to the Chairman of the Personnel Qualification Division, at the following address:

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RECOMMENDED PRACTICE NO. SNT-TC-1A

PERSONNEL QUALIFICATION AND CERTIFICATION IN NONDESTRUCTIVE TESTING

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, non-destructive 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 Par. 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 Par. 5, the employer shall review the detailed recommendations presented herein, and shall modify them as necessary to meet particular needs.

2. DEFINITIONS

- 2.1 Terms included in this document are defined as follows:
 - (1) Qualification — Demonstrated skill, training, knowledge and experience required for personnel to properly perform the duties of a specific job.
 - (2) Certification — Written testimony of qualification.
 - (3) Certifying Agency — The employer of the personnel being certified.
 - (4) Recommended Practice — A set of guidelines to assist the employer in developing uniform procedures for the qualification and certification of nondestructive testing personnel to satisfy the employer's specific requirements.
 - (5) Employer — The corporate, private, or public entity which employs personnel for wages, salary, fees, or other considerations.

- (6) Training — The program developed to impart the knowledge and skills necessary for qualification.
- (7) Outside Agency — A company or individual that provides NDT Level III services and whose qualifications to provide these services have been reviewed by the employer that engages the company or individual.

3. NONDESTRUCTIVE TEST METHODS

- 3.1 Qualification and certification of nondestructive testing personnel in accordance with this Recommended Practice is applicable to each of the following methods
 - (1) Radiographic Testing (RT)
 - (2) Magnetic Particle Testing (MT)
 - (3) Ultrasonic Testing (UT)
 - (4) Liquid Penetrant Testing (PT)
 - (5) Electromagnetic Testing (ET)
 - (6) Neutron Radiographic Testing (NRT)
 - (7) Leak Testing (LT)
 - (8) Acoustic Emission (AE)

4. LEVELS OF QUALIFICATION

- 4.1 There are three basic levels of qualification. These levels may be further subdivided by the employer for specific situations where additional levels of skills and responsibilities are deemed necessary.
- 4.2 While in the process of being qualified and certified to NDT Level I, an individual should be considered a Trainee. A Trainee should work with a certified individual and shall not independently conduct any tests, interpret or evaluate the results of a test, or report test results.
- 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 tests, and specific evaluations for acceptance or rejection determinations according to written instructions and to record results. The NDT Level I shall 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 the individual is 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 prepare written instructions, and to organize and report the results of nondestructive tests.
- (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 test methods, techniques, and procedures to be used. The NDT Level III should be responsible for the NDT operations for which qualified and to which 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, and should be qualified to train and examine NDT Level I and Level II personnel for certification.

5. WRITTEN PRACTICE

- 5.1 The employer shall establish a written practice for the control and administration of NDT personnel training, examination, and certification.
- 5.2 The employer's written practice shall 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.

6. EDUCATION, TRAINING, AND EXPERIENCE REQUIREMENTS FOR INITIAL QUALIFICATION

- 6.1 Personnel considered for certification in nondestructive testing shall have sufficient education, training, and experience to ensure understanding of the principles and procedures of those areas of testing in which they are being considered for certification.
- 6.2 Documented training and/or experience gained in positions and activities equivalent 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 Par. 6.3.
- 6.3 To be considered for certification, a candidate should satisfy one of the following criteria for the applicable NDT level:
- 6.3.1 **NDT Levels I and II**
Table 6.3.1 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.

6.3.2 NDT Level III

- (1) Have graduated from a minimum four-year college or university curriculum with a degree in engineering or science plus one years experience in nondestructive testing in an assignment comparable to that of an NDT Level II in the applicable test method(s),
or:
(2) 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:
(3) Have four years experience in an assignment at least comparable to that of an NDT Level II in the applicable testing method(s).

When the individual is qualified by examination, the above requirements may be partially replaced by experience as a certified NDT Level II or in assignments at least comparable to NDT Level II, in other methods listed in Par. 3 of this Recommended Practice as defined in the employer's written practice.

7. TRAINING PROGRAMS

- 7.1 Personnel being considered for certification should complete sufficient organized training to become thoroughly familiar with the principles and practices of the specified test method related to the level of certification desired and applicable to the practices 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.
- 7.2.1 Recommended training course outlines for Levels I and II personnel and recommended references which may be used as technical source material are appended as follows:

Test Method	Training Course Table Number	Reference Table Number
Radiographic Testing	I-A	II-A
Magnetic Particle Testing	I-B	II-B
Ultrasonic Testing	I-C	II-C
Liquid Penetrant Testing	I-D	II-D
Electromagnetic Testing	I-E	II-E
Neutron Radiographic Testing	I-F	II-F
Leak Testing	I-G	II-G
Acoustic Emission	I-H	II-H

8. EXAMINATIONS

- 8.1 An NDT Level III individual or his designated representative should administer and grade examinations. The examinations to verify physical and technical qualifications should consist of the following:
- 8.1.1 **Physical**
(1) 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 inches (30.5 cm) on a standard Jaeger test chart. The ability to perceive an Ortho-Rater minimum of 8 or similar tests pattern is also acceptable.

- (2) The examination should demonstrate the capability of distinguishing and differentiating contrast between colors used in the method.
- (3) The examination should demonstrate additional physical capabilities as required by the employer.
- (4) The examination should be administered on an annual basis.
- (5) Examination results are to be kept on file for the period of certification (see Par. 9.7).

8.1.2 General (Written) (For NDT Levels I and II)

- (1) The general examinations should be addressed to the basic principles of the applicable method.
- (2) In preparing the examination, the employer should select or devise appropriate questions covering the applicable method to the degree required by the employer's written practice.
- (3) The questions and answers provided in the applicable separate Question Booklets (See 8.2) are suggested as guidelines for the development of the general examination.

8.1.3 Specific (Written) (For NDT Levels I and II)

- (1) The specific examination should address the equipment, operating procedures, and test techniques that the applicant 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 by the employer in his nondestructive testing procedures.

8.1.4 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 test analyzed by the candidate.
- (3) The description of the specimen, the test procedure, including check points, and the results of the examination should be documented.

8.1.5 NDT Level III Examinations should be in accordance with Par. 8.3.3.

8.2 Suggested examination questions and answers for use in compiling appropriate general examinations are presented in the separate Question Booklets which can be obtained from ASNT Headquarters. The following is a list of the booklets.

Test Method	Question Booklets
Radiographic Testing	A
Magnetic Particle Testing	B
Ultrasonic Testing	C
Liquid Penetrant Testing	D
Electromagnetic Testing	E
Neutron Radiographic Testing	F
Leak Testing	G
Acoustic Emission	H

8.3

The following paragraphs describe the recommended examinations for each NDT level for the various nondestructive testing methods. The written examinations should be administered without access to reference material (closed book) except that necessary data, such as graphs, tables, specifications, procedures, and codes, may be provided. All questions used for Level I and Level II examinations shall be approved by the responsible Level III.

8.3.1 NDT Level I

- (1) General Examination — The recommended minimum number of Level I questions which should be given are:

Test Method	Number of Questions
Radiographic Testing	40
Magnetic Particle Testing	30
Ultrasonic Testing	40
Liquid Penetrant Testing	30
Electromagnetic Testing	40
Neutron Radiographic Testing	40
Leak Testing	20
Acoustic Emission	40

- (2) Specific Examination — The recommended minimum number of questions which should be given are:

Test Method	Number of Questions
Radiographic Testing	20
Magnetic Particle Testing	20
Ultrasonic Testing	20
Liquid Penetrant Testing	20
Electromagnetic Testing	20
Neutron Radiographic Testing	15
Leak Testing	
1. Bubble Test	15
2. Absolute Pressure Leak Test (Pressure Change)	15
3. Halogen Diode Leak Test	15
4. Mass Spectrometer Leak Test	20

- (3) Practical Examination — Proficiency shall be demonstrated in performing the applicable nondestructive tests on one or more samples approved by the NDT Level III. At least ten different checkpoints requiring an understanding of test variables and the employer's procedural requirements shall be included in the practical examination.

8.3.2 NDT Level II

- (1) General Examination — The recommended minimum number of Level II questions to be given are:

Test Method	Number of Questions
Radiographic Testing	40
Magnetic Particle Testing	30
Ultrasonic Testing	40
Liquid Penetrant Testing	30
Electromagnetic Testing	40
Neutron Radiographic Testing	40
Leak Testing	20
Acoustic Emission	40

- (2) Specific Examination — The recommended minimum number of questions to be given are:

Test Method	Number of Questions
Radiographic Testing	20
Magnetic Particle Testing	15
Ultrasonic Testing	20
Liquid Penetrant Testing	15
Electromagnetic Testing	20
Neutron Radiographic Testing	15
Leak Testing	
1. Bubble Test	15
2. Absolute Pressure Leak Test (Pressure Change)	15
3. Halogen Diode Leak Test	15
4. Mass Spectrometer Leak Test	40
Acoustic Emission	20

- (3) Practical Examination — Proficiency should be demonstrated in selecting and performing the applicable nondestructive tests and interpreting and evaluating the results on one or more samples approved by the NDT Level III. At least ten different check-points requiring an understanding of test variables and the employer's procedural requirements should be included in this practical examination.

8.3.3 NDT Level III

- (1) Basic Examination (Required only once when more than one method of examination is taken).
- (a) Twenty (20) questions relating to understanding the SNT-TC-1A document.
 - (b) Fifteen (15) questions relative to applicable materials, fabrication, and product technology
 - (c) Fifteen (15) questions which are selected from or 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, which are selected from or are similar to published ASNT Level III questions for each method, and
 - (b) Fifteen (15) questions relating to application and establishment of techniques and procedures which are selected from or are similar to the published ASNT 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.

8.3.4 On the basis of demonstrated ability, achievement, experience, and education, as defined in Par. 4.3(3) and 6.3, the employer may waive examination for the Level III individual. Written certification should be provided, and evidence supporting the certification should be held on file and be made available when verification is required.

8.3.5(a) A valid endorsement on an ASNT NDT Level III certificate fulfills the examination criteria described in Paragraph 8.3.3(1) and 8.3.3(2) for each applicable NDT method.

8.3.5(b) The employer may delete the Specific examination described in Paragraph 8.3.3(3)(a) 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.

8.4 Grading

8.4.1 An NDT Level III shall be responsible for the administration and grading of examinations for NDT Level I and II personnel. The administration and grading of examinations may be delegated to a designated representative of the NDT Level III and so recorded. The employer shall be responsible for administration and grading of examinations for Level III personnel. The actual administration and grading of Level III examinations may be performed by a designated representative of the employer.

8.4.2 A composite grade based upon the general, specific, and practical or upon the basic, method, and specific examinations should be developed by the employer. The composite grade may be a simple average of the examinations or may be developed by applying a weighting factor to each examination. The method of arriving at the composite grade prescribed in the employer's written practice should not be changed indiscriminately to fit the capabilities of the candidate.

8.4.3 When weighting factors are used, the total of the weighting factors shall equal 1.0. The weighting factors should be within the following ranges:

- (1) NDT Level I Weighting Factors
 - (a) General — 0.2 to 0.6
 - (b) Specific — 0.2 to 0.5
 - (c) Practical — 0.3 to 0.7
- (2) NDT Level II Weighting Factors
 - (a) General — 0.3 to 0.7
 - (b) Specific — 0.2 to 0.6
 - (c) Practical — 0.2 to 0.5
- (3) NDT Level III Weighting Factors
 - (a) Basic — 0.2 to 0.5
 - (b) Method — 0.3 to 0.6
 - (c) Specific — 0.2 to 0.4
- (4) The composite grade (Gc) is determined as follows:

$$\text{Levels I and II; } Gc = (Gg \times Wg) + (Gs \times Ws) + (Gp \times Wp)$$

$$\text{Level III; } Gc = (Gb \times Wb) + (Gm \times Wm) + (Gs \times Ws)$$

Where Gc = Composite grade

Gg = Actual grade from general examination in percent

Wg = Weighting factor of general examination

Gs = Actual grade from specific examination in percent

Ws = Weighting factor of specific examination

Gp = Actual grade from practical examination in percent

Wp = Weighting factor of practical examination

Gb = Actual grade from basic examination in percent

Wb = Weighting factor of basic examination

Gm = Actual grade from method examination in percent

Wm = Weighting factor of method examination

- 8.4.4** When an examination is administered for qualification, a composite passing grade of 80% or greater is recommended. In addition, each passing grade for the general, specific, and practical or the basic, method, and specific examination is recommended to be 70% or greater. Test objects should be used in the practical examination when appropriate.
- 8.4.5** When 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% for that particular examination.
- 8.5 Reexamination**
- (1) Those failing to attain the required grades must wait at least 30 days or show evidence of having received suitable additional training as determined by the employer before reexamination.

9. CERTIFICATION

- 9.1** Certification of all levels of NDT personnel is the responsibility of the employer.
- 9.2** The employer shall establish written practices covering all phases of certification including training as specified in Par. 5.
- 9.3** Certification of NDT personnel shall be based on demonstration of satisfactory qualification as determined by procedures outlined in Par. 6, 7, and 8 as modified by the employer's written practices.
- 9.4** 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 must be retained by the employer.
- 9.5** The employer who purchases outside services is responsible for assuring that training and examination services are in accordance with the employer's written practices.
- 9.6** Personnel certifications and copies of the employer's written practices shall be maintained on file by the employer.
- 9.6.1** The qualification records of the certified individuals shall be maintained by the employer and should include the following:
- (1) Name of certified individual.
 - (2) Level of certification and test method.
 - (3) Educational background and experience of certified individuals.
- (4) Statement indicating satisfactory completion of training in accordance with the employer's written procedure.
 - (5) Results of the physical examination prescribed in Par. 8.1.1.
 - (6) Current examination copy(s) or evidence of successful completion of the examinations
 - (7) Other suitable evidence of satisfactory qualifications when such qualifications are used in lieu of examinations.
 - (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 designated representative.

9.7 Recertification

- 9.7.1** All levels of NDT personnel should be recertified periodically in accordance with one of the following criteria:
- (1) Evidence of continuing satisfactory performance.
 - (2) Reexamination in those portions of the examinations in Par. 8.3 deemed necessary by the employer's NDT Level III.
- 9.7.2** Recommended maximum recertification intervals are:
- (1) Levels I and II - 3 years
 - (2) Level III - 5 years
- 9.7.3** NDT personnel may be reexamined any time at the discretion of the employer and have their certifications extended or revoked.
- 9.7.4** The employer's written practice should include rules covering the duration of interrupted service which will require reexamination and recertification.

10. TERMINATION

- 10.1** The employer's certification shall be deemed revoked when employment is terminated.
- 10.2** A Level I, Level II, or Level III whose certification has been terminated may be recertified to his former NDT level by a new employer based on examination as described in Par. 8 provided all of the following conditions are met to the new employer's satisfaction:
- (1) The employee has proof of prior certification.
 - (2) The employee was working in the capacity to which he certified within six months of termination.
 - (3) The employee is being recertified within six months of his termination.

Table 6.3.1
RECOMMENDED INITIAL TRAINING AND EXPERIENCE LEVELS
TRAINING (HOURS)

Examination Method	RT		MT		UT		PT		ET		NRT		AE		LT							
Level	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I				II			
Technique															BT	PCMT	HDLT	MSLT	BT	PCMT	HDLT	MSLT
Completion with a passing grade of at least 2 years of engineering or science study in a university, college, or technical school	29	35	8	4	24	40	4	4	8	8	20	40	40	35	2	16	8	28	2	12	6	16
High School graduation or equivalent	39	40	12	8	40	40	4	8	12	8	28	40	60	65	2	24	12	40	4	16	8	24
Grammar school graduation, or demonstration proficiency, or additional training	88	80	24	16	40	80	12	16	48	24	56	80	80	85	2	60	24	60	4	80	20	80
All educational levels as listed above	3	9	1	3	3	9	1	2	1	9	6	24	6	18	*	1½	1½	4	½	4	4	6

BT = Bubble Test

PCMT = Pressure Change/Measurement Test

HDLT = Halogen Diode Leak Test

MSLT = Mass Spectrometer Leak Test

* = 2 Hours

NOTES:

- (1) For Level II certification, the experience should 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 should consist of the sum of the times required for Level I and Level II and the required training should consist of the sum of the hours required for Level I and Level II.
- (2) Listed training guidelines may be prorated as described in the employer's written practice depending on the candidate's actual educational level.
- (3) Initial experience may be gained simultaneously in two or more methods if:
 - (a) The candidate spends a minimum of 25% of his work time on each method for which certification is sought, and
 - (b) The remainder of his work time claimed as experience is spent in NDT-related activities as defined in the employer's written practice.
- (4) Training should be outlined in the employer's written practice.

Recommended Training Course

Radiography Testing Method

	Recommended Hours of Instruction		
	1*	2*	3*
Level I			
Radiographic Equipment Operating & Emergency Instructions Course	8	4	4
Basic Radiographic Physics Course	40	20	15
Radiographic Technique Course	40	15	10
Total	88	39	29
Level II			
Film Quality and Manufacturing Processes Course	40	20	15
Radiographic Evaluation and Interpretation Course	40	20	20
Total	80	40	35

*Note: 1. Grammar School Graduate
 2. High School Graduate or Equivalent
 3. Completion with passing grades of at least two years of Engineering or Science Study at a University, College, or Technical School.

Recommended Training for Level I Radiographer

Radiographic Equipment Operating and Emergency Instructions Course

Note: It is recommended that the trainee receive instruction in this course prior to performing work in radiography.

1. Personnel Monitoring

- 1.1 Wearing of Personnel Monitoring Badges
- 1.2 Reading of Pocket Dosimeters
- 1.3 Recording of Daily Dosimeter Readings
- 1.4 "Offscale" Dosimeter - Action Required
- 1.5 Permissible Personnel Exposure Limits

2. Survey Instruments

- 2.1 Types of Radiation Survey Instruments
- 2.2 Reading and Interpreting Survey Instrument Meter Indications

RADIOGRAPHY TESTING

- 2.3 Calibration Frequency
- 2.4 Calibration Expiration - Action
- 2.5 Battery Check - Importance

3. Leak Test of Sealed Radioactive Sources

- 3.1 Requirements for Leak Test
- 3.2 Purpose of Leak Test
- 3.3 Performance of the Leak Test

4. Radiological Survey Reports

- 4.1 Requirements for Completing
- 4.2 Description of Report Format

5. Radiography Work Practices

- 5.1 Establishment of Restricted Areas
- 5.2 Posting and Surveillance of Area
- 5.3 Use of Time, Distance and Shielding to Reduce Personnel Radiation Exposure
- 5.4 Applicable Regulatory Requirements for Surveys, Posting and Control of Radiation and High Radiation Areas

6. Exposure Devices

- 6.1 Daily Inspection and Maintenance for Exposure Devices
- *6.2 Radiation Exposure Limits for Gamma Ray Exposure Devices
- 6.3 Labeling of Exposure Devices
- 6.4 Use of Exposure Devices
- 6.5 Use of Collimators to Reduce Personnel Exposure
- *6.6 Use of "Source Changers" from Gamma Ray Sources

7. Storage and Shipment of Exposure Devices and Sources

- *7.1 Vehicle Accidents with Radioactive Sealed Sources
- *7.2 Fire Involving Sealed Sources
- *7.3 "Source Out" — Failure to Return to Safe Shielded Conditions
- *7.4 Emergency Call List

8. State and Federal Regulations

- 8.1 The NRC and Agreement States — Authority
- 8.2 License Reciprocity
- *8.3 Radioactive Materials License Requirements for Industrial Radiography
- 8.4 Qualification Requirements for Radiography Personnel
- 8.5 Regulations for the Control of Radiation (State or NRC as Applicable)
- *8.6 Department of Transportation Regulations for Radiography Source Shipment
- 8.7 Regulatory Requirements for X-ray Machines (State & Federal as Applicable)

Total Recommended Hours of Instruction this Course: $\frac{1}{8 \text{ hr.}}$ $\frac{2}{4 \text{ hr.}}$ $\frac{3}{4 \text{ hr.}}$

*NOTE: Topics so indicated * may be deleted if the Radiography is limited to X-ray exposure devices.

RECOMMENDED TRAINING FOR LEVEL I RADIOGRAPHER

Basic Radiography Physics Course

1. Introduction

- 1.1 History and Discovery of Radioactive Materials
- 1.2 Definition of Industrial Radiography
- 1.3 Radiation Protection, Why?
- 1.4 Basic Math Review, Exponents, Square Root, Etc.

2. Fundamental Properties of Matter

- 2.1 Elements and Atoms

RADIOGRAPHY TESTING

- 2.2 Molecules and Compounds
- 2.3 Atomic Particles, Properties of Protons, Electrons, and Neutrons
- 2.4 Atomic Structure
- 2.5 Atomic Number and Weight
- 2.6 Isotope Versus Radioisotope

3. Radioactive Materials

- 3.1 Production of Radioactive Materials
 - (a) Neutron Activation
 - (b) Nuclear Fission
- 3.2 Stable Versus Unstable (radioactive) Atoms
- 3.3 Curie — the Unit of Activity
- 3.4 Half-life of Radioactive Materials
- 3.5 Plotting of Radioactive Decay
- 3.6 Specific Activity — Curies/Gram

4. Types of Radiation

- 4.1 Particulate Radiation-Properties: Alpha, Beta, Neutron
- 4.2 Electromagnetic Radiation — X-ray, Gamma Ray
- 4.3 X-ray Production
- 4.4 Gamma Ray Production
- 4.5 Gamma Ray Energy
- 4.6 Energy Characteristics of Common Radioisotope Sources
- 4.7 Energy Characteristics of X-ray Machines

5. Interaction of Radiation with Matter

- 5.1 Ionization
- 5.2 Radiation Interaction with Matter
 - (a) Photoelectric Effect
 - (b) Compton Scattering
 - (c) Pair Production
- 5.3 The Unit of Radiation Exposure — the Roentgen
- 5.4 Emissivity of Commonly used Radiography Sources
- 5.5 Emissivity of X-ray Exposure Devices
- 5.6 Attenuation of Electromagnetic Radiation — Shielding
- 5.7 Half Value Layers/Tenth Value Layers
- 5.8 Inverse Square Law

6. Biological Effects of Radiation

- 6.1 “Natural” Background Radiation
- 6.2 The Unit of Radiation Dose — Rem
- 6.3 The Difference Between Radiation and Contamination
- 6.4 Allowable Personnel Exposure Limits and the Banking Concept
- 6.5 Theory of Allowable Dose
- 6.6 Radiation Damage — Repair Concept
- 6.7 Symptoms of Radiation Injury
- 6.8 Acute Radiation Exposure and Somatic Injury
- 6.9 Personnel Monitoring for Tracking Exposure
- 6.10 Organ Radiosensitivity

7. Radiation Detection

- 7.1 The Pocket Dosimeter
- 7.2 The Difference Between Dose and Dose Rate
- 7.3 Survey Instruments:
 - Geiger Muller Tube
 - Ionization Chambers
 - Scintillation Chambers Counters
- 7.4 Film Badge — Radiation Detector
- 7.5 TLD (Thermoluminescent Dosimeters)
- 7.6 Calibration of Survey Instruments

RADIOGRAPHY TESTING

8. Exposure Devices and Radiation Sources

- 8.1 Radioisotope Sources
 - (a) Sealed Source Design and Fabrication
 - (b) Gamma Ray Sources
 - (c) Beta and Bremsstrahlung Sources
 - (d) Neutron Sources
- 8.2 Radioisotope Exposure Device Characteristics
- 8.3 Electronic Radiation Sources — 500 kev & Less — Low Energy
 - (a) Generator — High Voltage Rectifiers
 - (b) X-ray Tube Design and Fabrication
 - (c) X-ray Control Circuits
 - (d) Accelerating Potential
 - (e) Target Material and Configuration
 - (f) Heat Dissipation
 - (g) Duty Cycle
 - (h) Beam Filtration
- *8.4 Electronic Radiation Sources — Medium & High Energy
 - *(a) Resonance Transformer
 - *(b) Van de Graaff Accelerator
 - *(c) Linac
 - *(d) Betatron
 - *(e) Roentgen Output
 - *(f) Equipment Design & Fabrication
 - *(g) Beam Filtration
- *8.5 Fluoroscopic Radiation sources
 - *(a) Fluoroscopic Equipment Design
 - *(b) Direct Viewing Screens
 - *(c) Image Amplification
 - *(d) Special X-ray Tube Considerations & Duty Cycle
 - *(e) Screen Unsharpness
 - *(f) Screen Conversion Efficiency

9. Special Radiographic Sources and Techniques

- *9.1 Flash Radiography
- *9.2 Stereo Radiography
- *9.3 In Motion Radiography
- *9.4 Auto Radiography

Total Recommended Hours of Instruction this Course: $\frac{1}{40 \text{ hr.}}$ $\frac{2}{20 \text{ hr.}}$ $\frac{3}{15 \text{ hr.}}$

*NOTE: Topics so indicated * may be deleted if these methods and techniques are not used by the employer.

RECOMMENDED TRAINING FOR LEVEL I RADIOGRAPHER

Radiography Technique Course

1. Introduction

- 1.1 The Process of Radiography
- 1.2 Types of Electromagnetic Radiation Sources
- 1.3 The Electromagnetic Spectrum
- 1.4 Penetrating Ability or “Quality” of X-rays and Gamma Rays
- 1.5 Spectrum of X-ray Tube source
- 1.6 Spectrum of Gamma Radioisotope Source
- 1.7 X-ray Tube — Change of ma or kvp Effect on “Quality” and Intensity

RADIOGRAPHY TESTING

2. Basic Principles of Radiography

- 2.1 Geometric Exposure Principles
 - (a) “Shadow” Formation and Distortion
 - (b) Shadow Enlargement Calculation
 - (c) Shadow Sharpness
 - (d) Geometric Unsharpness
 - (e) Finding Depth of Discontinuity
- 2.2 Radiographic Screens
 - (a) Lead Intensifying Screens
 - (b) Fluorescent Intensifying Screens
 - (c) Intensifying Factors
 - (d) Importance of Screen/Film Contact
 - (e) Importance of Screen Cleanliness and Care
 - (f) Techniques for Cleaning Screens
- 2.3 Radiographic Cassettes
- 2.4 Composition of Industrial Radiographic Film
- 2.5 The “Heel Effect” with X-ray Tubes

3. The Radiograph

- 3.1 Formation of the Latent Image on Film
- 3.2 Inherent Unsharpness
- 3.3 Arithmetic of Radiograph Exposure
 - (a) Milliamperage — Distance — Time Relationship
 - (b) The Reciprocity Law
 - (c) Photographic Density
 - (d) X-ray Exposure Charts (Material Thickness, kv, and Exposure)
 - (e) Gamma Ray Exposure Chart
 - (f) Inverse Square Law Considerations
 - (g) Calculation of Exposure Time for Gamma and X-ray Sources
- 3.4 The Characteristic (H and D) Curve
- 3.5 Film Speed and Class Descriptions
- 3.6 Selection of Film for Particular Purpose

4. Radiographic Image Quality

- 4.1 Radiographic Sensitivity
- 4.2 Radiographic Contrast
- 4.3 Film Contrast
- 4.4 Subject Contrast
- 4.5 Definition
- 4.6 Film Graininess and Screen Mottle Effects
- 4.7 Penetrameters or Image Quality Indicators

5. Film Handling, Loading, and Processing

- 5.1 Safelight and Darkroom Practices
- 5.2 Loading Bench and Cleanliness
- 5.3 Opening of Film Boxes and Packets
- 5.4 Loading of Film and Sealing Cassettes
- 5.5 Handling Techniques for “Green Film”
- 5.6 Elements of Manual Film Processing

6. Exposure Techniques — Radiography

- 6.1 Single Wall Radiography
- 6.2 Double Wall Radiography
 - (a) Viewing Two Walls Simultaneously
 - (b) Offset Double Wall Exposure Single Wall Viewing
 - (c) Elliptical Techniques
- 6.3 Panoramic Radiography
- 6.4 Use of Multiple Film Loading
- 6.5 Specimen Configuration

RADIOGRAPHY TESTING

7. Fluoroscopic Techniques

- 7.1 Dark Adaptation and Eye Sensitivity
- 7.2 Special Scattered Radiation Techniques
- 7.3 Personnel Protection
- 7.4 Sensitivity
- 7.5 Limitations
- 7.6 Direct Screen Viewing
- 7.7 Indirect and Remote Screen Viewing

Total Recommended Hours of Instruction this Course: $\frac{1}{40 \text{ hr.}}$ $\frac{2}{15 \text{ hr.}}$ $\frac{3}{10 \text{ hr.}}$

RECOMMENDED TRAINING FOR LEVEL II RADIOGRAPHER

Film Quality and Manufacturing Processes Course

1. Review of Basic Radiographic Principals

- 1.1 Interaction of Radiation with Matter
- 1.2 Math Review
- 1.3 Exposure Calculations
- 1.4 Geometric Exposure Principals
- 1.5 Radiographic Image Quality Parameters

2. Dark Room Facilities, Techniques, and Processing

- 2.1 Facilities and Equipment
 - (a) Automatic Film Processor versus Manual Processing
 - (b) Safe Lights
 - (c) View Lights
 - (d) Loading Bench
 - (e) Miscellaneous Equipment
- 2.2 Film Loading
 - (a) General Rules for Handling Unprocessed Film
 - (b) Types of Film Packaging
 - (c) Cassette Loading Techniques for Sheet and Roll
- 2.3 Protection of Radiographic Film in Storage
- 2.4 Processing of Film — Manual
 - (a) Developer and Replenishment
 - (b) Stop Bath
 - (c) Fixer and Replenishment
 - (d) Washing
 - (e) Prevention of Water Spots
 - (f) Drying
- 2.5 Automatic Film Processing
- 2.6 Film Filing and Storage
 - (a) Retention Life Measurements
 - (b) Long Term Storage
 - (c) Filing and Separation Techniques
- 2.7 Unsatisfactory Radiographs, Causes and Cures
 - (a) High Film Density
 - (b) Insufficient Film Density
 - (c) High Contrast
 - (d) Low Contrast
 - (e) Poor Definition
 - (f) Fog
 - (g) Light Leaks
 - (h) Artifacts
- 2.8 Film Density
 - (a) Step Wedge Comparison Film
 - (b) Densitometers

RADIOGRAPHY TESTING

3. Indications, Discontinuities and Defects

- 3.1 Indications
- 3.2 Discontinuities
 - (a) Inherent
 - (b) Processing
 - (c) Service
- 3.3 Defects

4. Manufacturing Processes and Associated Discontinuities

- 4.1 Casting Processes and Associated Discontinuities
 - (a) Ingots, Blooms and Billets
 - (b) Sand Casting
 - (c) Centrifugal Casting
 - (d) Investment Casting
- 4.2 Wrought Processes and Associated Discontinuities
 - (a) Forgings
 - (b) Rolled Products
 - (c) Extruded Products
- 4.3 Welding Processes and Associated Discontinuities
 - (a) Submerged Arc Welding — SAW
 - (b) Shielded Metal Arc Welding — SMAW
 - (c) Gas Metal Arc Welding — GMAW
 - (d) Flux Cored Arc Welding — FCAW
 - (e) Gas Tungsten Arc Welding — GTAW
 - (f) Resistance Welding
 - (g) Special Welding Processes, Electron Beam, Electroslag, Electrogas, etc.

5. Radiological Safety Principals Review

- 5.1 Controlling Personnel Exposure
- 5.2 Time, Distance, Shielding Concepts
- 5.3 ALARA Concepts
- 5.4 Radiation Detection Equipment
- 5.5 Exposure Device Operating Characteristics

Total Recommended Hours of Instruction this Course:	$\frac{1}{40 \text{ hr.}}$	$\frac{2}{20 \text{ hr.}}$	$\frac{3}{15 \text{ hr.}}$
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