

Recommended Practice No.

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SNT-TC-1A

2001



**The American Society for
Nondestructive Testing, Inc.**

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

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**The American Society for
Nondestructive Testing, Inc.**

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Former editions of *SNT-TC-1A* used a variety of paragraph numbering schemes, and several of those were imported into later editions of the document, including the 1996 edition. The 2001 edition standardizes all paragraph numbering into a single format that is consistent throughout the document.

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FOREWORD

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, purchaser and supplier must agree upon acceptability of an employer's program.

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.

The 2001 Edition of *SNT-TC-1A* is annotated so that users of the 1996 Edition can quickly and easily locate new and updated material. The vertical lines in the margins of this document indicate that information in the text has been modified in some way.

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Recommended Practice No. SNT-TC-1A

Personnel Qualification and Certification in Nondestructive Testing

1.0 Scope

- 1.1 It is recognized that the effectiveness of nondestructive testing (NDT) applications depends upon the capabilities of the personnel who are responsible for and perform, NDT. This Recommended Practice has been prepared to establish guidelines for the qualification and certification of NDT 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, Inc., to aid employers in recognizing the essential factors to be considered in qualifying personnel engaged in any of the NDT 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.

2.0 Definitions

- 2.1 Terms included in this document are defined as follows:
 - 2.1.1 Certification: written testimony of qualification.
 - 2.1.2 Certifying Authority: the person or persons properly designated in the written practice to sign certifications on behalf of the employer.
 - 2.1.3 Certifying Agency: the employer of the personnel being certified.
 - 2.1.4 Closed Book Examination: an examination administered without access to reference material except for materials supplied with or in the examination. (See 8.7.)
 - 2.1.5 Comparable: being at an equivalent or similar level of NDT responsibility and difficulty as determined by the employer's Level III.
 - 2.1.6 Documented: the condition of being in written form.
 - 2.1.7 Employer: the corporate, private, or public entity, which employs personnel for wages, salary, fees, or other considerations.
 - 2.1.8 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.
 - 2.1.9 Nondestructive Testing: a process that involves the inspection, testing, or evaluation of materials, components and assemblies for materials' discontinuities, properties and machine problems without further impairing or destroying the parts serviceability. Throughout this document the term NDT applies equally to the NDT inspection methods used for material inspection, flaw detection or predictive maintenance (PdM) applications.
 - 2.1.10 Outside Agency: a company or individual who provides NDT Level III services and whose qualifications to provide these services have been reviewed and approved by the employer engaging the company or individual.
 - 2.1.11 Qualification: demonstrated skill and knowledge, along with documented training and experience required for personnel to properly perform the duties of a specific job.
 - 2.1.12 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.
 - 2.1.13 Training: an organized program developed to impart the knowledge and skills necessary for qualification.

- 2.1.14 Written Practice: a written procedure developed by the employer that details the requirements for qualification and certification of their employees.

3.0 Nondestructive Testing Methods

- 3.1 Qualification and certification of NDT personnel in accordance with this Recommended Practice is applicable to each of the following methods:

- Acoustic Emission Testing
- Electromagnetic Testing
- Laser Testing Methods
- Leak Testing
- Liquid Penetrant Testing
- Magnetic Particle Testing
- Neutron Radiographic Testing
- Radiographic Testing
- Thermal/Infrared Testing
- Ultrasonic Testing
- Vibration Analysis
- Visual Testing

4.0 Levels of Qualification

- 4.1 There are three basic levels of qualification. The employer may subdivide these levels 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. The trainee shall not independently conduct, interpret, evaluate, or report the results of any NDT test.
- 4.3 The three basic levels of qualification are as follow:
- 4.3.1 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.
 - 4.3.2 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 tests.
 - 4.3.3 NDT Level III. An NDT Level III individual should be capable of developing, qualifying, and approving procedures, establishing and approving techniques, 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 when none are otherwise available. The NDT Level III should have general familiarity with other appropriate NDT methods, as demonstrated by an 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 II personnel for certification in those methods.

5.0 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 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.
- 5.3 The employer's written practice shall describe the training, experience and examination requirements for each level of certification.
- 5.4 The employer's written practice shall be reviewed and approved by the employer's NDT Level III.
- 5.5 The employer's written practice shall be maintained on file.

6.0 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 Section 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 6.3.1A (page 10) 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 (page 11) 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.
 - 6.3.2 NDT Level III
 - 6.3.2.1 Have graduated from a minimum four-year college or university curriculum with a degree in engineering or science, plus one additional year of experience beyond the level II requirements in NDT in an assignment comparable to that of an NDT Level II in the applicable NDT method(s), or:
 - 6.3.2.2 Have completed with passing grades at least two years of engineering or science study at a university, college, or technical school, plus two additional years of experience beyond the level II requirements in NDT in an assignment at least comparable to that of NDT Level II in the applicable NDT method(s), or:
 - 6.3.2.3 Have four years of experience beyond the level II requirements in NDT in an assignment at least comparable to that of an NDT Level II in the applicable NDT 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 NDT Level as defined in the employer's written practice.

7.0 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 ensure understanding of the necessary information.
- 7.3 Recommended training course outlines and references for NDT Levels I, II and III which may be used as technical source material are contained in the Recommended Training Courses section of this Recommended Practice.
- 7.4 The employer who purchases outside training services is responsible for ensuring that such services meet the requirements of the employer's written practice.

8.0 Examinations

8.1 Administration and Grading

- 8.1.1 An NDT Level III 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. A qualified representative of the employer may perform the actual administration and grading of Level III examinations specified in 8.8.
- 8.1.2 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.
- 8.1.3 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.
- 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.
- 8.1.5 The employer who purchases outside services is responsible for ensuring that the examination services meet the requirements of the employer's written practice.

8.2 Vision Examinations

- 8.2.1 Near-Vision Acuity: The examination should ensure 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 letter at the distance designated on the chart but 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 test pattern is also acceptable. This should be administered annually.
- 8.2.2 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)

- 8.3.1 The general examinations should address the basic principles of the applicable method.
- 8.3.2 In preparing the examinations, the NDT Level III should select or devise appropriate questions covering the applicable method to the degree required by the employer's written practice.
- 8.3.3 See the Appendix for example questions.
- 8.3.4 The minimum number of questions that should be given is as follows:

Test Method	Number of Level I Questions	Number of Level II Questions
Acoustic Emission Testing	40	40
Electromagnetic Testing	40	40
Laser Testing	30	30
Leak Testing	20	20
Liquid Penetrant Testing	40	40
Magnetic Particle Testing	40	40
Neutron Radiographic Testing	40	40
Radiographic Testing	40	40
Thermal/Infrared Testing	40	40
Ultrasonic Testing	40	40
Vibration Analysis	40	40
Visual Testing	40	40

8.4 Specific (written for NDT Levels I and II)

- 8.4.1 The specific examination should address the equipment, operating procedures and NDT techniques that the individual may encounter during specific assignments to the degree required by the employer's written practice.
- 8.4.2 The specific examination should also cover the specifications or codes and acceptance criteria used in the employer's NDT procedures.
- 8.4.3 The minimum number of questions that should be given is as follows:

Test Method	Number of Level I Questions	Number of Level II Questions
Acoustic Emission Testing	20	20
Electromagnetic Testing	20	20
Laser Testing:		
1. Profilometry	20	20
2. Holography/Shearography	20	20
Leak Testing:		
1. Bubble Test	15	15
2. Absolute Pressure Leak Test (Pressure Change)	15	15
3. Halogen Diode Leak Test	15	15
4. Mass Spectrometer Leak Test	20	40
Liquid Penetrant Testing	20	20
Magnetic Particle Testing	20	20
Neutron Radiographic Testing	15	15
Radiographic Testing	20	20
Thermal/Infrared Testing	20	20
Ultrasonic Testing	20	20
Vibration Analysis	20	60
Visual Testing	20	20

- 8.5 Practical (for NDT Level I and II)
- 8.5.1 The candidate should demonstrate familiarity with and ability to operate the necessary NDT equipment, record and analyze the resultant information to the degree required.
 - 8.5.2 At least one flawed specimen or component should be tested and the results of the NDT test analyzed by the candidate.
 - 8.5.3 The description of the specimen, the NDT procedure, including check points, and the results of the examination should be documented.
 - 8.5.4 NDT Level I Practical Examination. Proficiency should be demonstrated in performing the applicable NDT on one or more specimens or machine problems 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.
 - 8.5.5 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 specimens or machine problems 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 the separate question booklets that can be obtained from ASNT Headquarters. These questions are intended as examples only and should not be used verbatim for qualification examinations. The following is a list of the booklets:

Question Test Method	Booklets
Acoustic Emission Testing	G
Electromagnetic Test (Eddy Current and Flux Leakage)	E
Laser Testing	
1. Profilometry	LP*
2. Holography/Shearography	LH*
Leak Testing	
1. Bubble Test	HB
2. Pressure Change Measurement	HP
3. Halogen Diode Leak Test	HH
4. Mass Spectrometer Test	HM
Liquid Penetrant Testing	D
Magnetic Particle Testing	B
Neutron Radiographic Testing	F
Radiographic Testing	A
Thermal/Infrared Testing	J*
Ultrasonic Testing	C
Vibration Analysis	K*
Visual Testing	I

* In course of preparation

- 8.7 Additional Written, Specific and Practical Examination Criteria
- 8.7.1 Level I, II and III Written Examinations
 - 8.7.1.1 All Level I, II and III written examinations should be closed book except that necessary data, such as graphs, tables, specifications, procedures,

- codes, etc., 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.
- 8.7.1.2 A valid endorsement on an ACCP Level I or Level II certificate fulfills the corresponding examination criteria described in paragraphs 8.3 and 8.5 for each applicable NDT method.
 - 8.7.1.3 The employer may delete the specific examination (paragraph 8.4) if the candidate has a valid ACCP certificate, provided the examinations administered meet the technical needs of the employer.
 - 8.7.2 Level I and II Specific Examinations
The employer may delete the specific examination if the candidate has a valid ACCP Level I or Level II certificate in the method and if documented experience exists to permit such.
 - 8.7.3 Practical Examinations
Successful completion of ACCP Level I or Level II general hands-on practical examinations may be considered as fulfilling the requirements of paragraphs 8.3 and 8.5 respectively.
 - 8.8 NDT/PdM Level III Examinations
 - 8.8.1 Basic Examinations
 - 8.8.1.1 NDT Basic Examination (required only once when more than one method examination is taken). The minimum number of questions that should be given is as follows:
 - 8.8.1.1.1 Fifteen (15) questions relating to understanding the *SNT-TC-1A* document.
 - 8.8.1.1.2 Twenty (20) questions relating to applicable materials, fabrication and product technology.
 - 8.8.1.1.3 Twenty (20) questions that are similar to published Level II questions for other appropriate NDT methods.
 - 8.8.1.2 PdM Basic Examination (required only once when more than one method examination is taken). The minimum number of questions that should be given is as follows:
 - 8.8.1.2.1 Fifteen (15) questions relating to understanding the *SNT-TC-1A* document.
 - 8.8.1.2.2 Twenty (20) questions relating to applicable machinery technology.
 - 8.8.1.2.3 Thirty (30) questions that are similar to published Level II questions for other appropriate PdM methods.
 - 8.8.2 Method Examination (for each method)
 - 8.8.2.1 Thirty (30) questions relating to fundamentals and principles that are similar to published ASNT Level III questions for each method, and
 - 8.8.2.2 Fifteen (15) questions relating to application and establishment of techniques and procedures that are similar to the published ASNT Level III questions for each method, and
 - 8.8.2.3 Twenty (20) questions relating to capability for interpreting codes, standards and specifications relating to the method.
 - 8.8.3 Specific Examination (for each method)
 - 8.8.3.1 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.
 - 8.8.3.2 The employer may delete the specific examination if the candidate has a valid ASNT Level III certificate in the method and if documented evidence of experience exists, including the preparation of procedures to codes, standards, or specifications and the evaluation of test results.
 - 8.8.4 A valid endorsement on an ASNT Level III certificate fulfills the examination criteria described in 8.8.1 and 8.8.2 for each applicable method.

- 8.8.5 A valid endorsement of an ACCP Professional Level III certificate fulfills the examination criteria described in 8.8.1 and 8.8.2 for each applicable method.
- 8.9 Reexamination
Those failing to attain the required grades should wait at least thirty (30) days or receive suitable additional training as determined by the Level III before reexamination.

9.0 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 described in 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 of the employees shall be retained by the employer.
- 9.4 Personnel certification records shall be maintained on file by the employer for the duration specified in the employer's written practice and shall include the following:
 - 9.4.1 Name of certified individual.
 - 9.4.2 Level of certification and NDT method.
 - 9.4.3 Educational background and experience of certified individuals.
 - 9.4.4 Statement indicating satisfactory completion of training in accordance with the employer's written practice.
 - 9.4.5 Results of the vision examinations prescribed in 8.2 for the current certification period.
 - 9.4.6 Current examination copy(ies) or evidence of successful completion of examinations.
 - 9.4.7 Other suitable evidence of satisfactory qualifications when such qualifications are used in lieu of the specific examination described in 8.8.3.2 or as prescribed in the employer's written practice.
 - 9.4.8 Composite grade(s) or suitable evidence of grades.
 - 9.4.9 Signature of the Level III that verified qualifications of candidate for certification.
 - 9.4.10 Date of certification and/or recertification and the date of assignments to NDT.
 - 9.4.11 Certification expiration date.
 - 9.4.12 Signature of employer's certifying authority.

10.0 Technical Performance Evaluation

- 10.1 NDT personnel may be reexamined any time at the discretion of the employer and have their certification extended or revoked.
- 10.2 Periodically, as defined in the employer's written practice, the technical performance of Level I and II personnel should be evaluated and documented by an NDT Level III. The evaluation and documentation should follow the format and guidelines described in section 8.5.

11.0 Interrupted Service

- 11.1 The employer's written practice should include rules covering the types and duration of interrupted service.
- 11.2 The written practice should specify the requirements for reexamination and/or recertification for the interrupted service.

12.0 Recertification

- 12.1 All levels of NDT personnel shall be recertified periodically in accordance with one of the following criteria:
 - 12.1.1 Evidence of continuing satisfactory technical performance.
 - 12.1.2 Reexamination in those portions of the examinations in Section 8 deemed necessary by the employer's Level III.
- 12.2 Recommended maximum recertification intervals are:

- 12.2.1 Levels I and II – 3 years
- 12.2.2 Level III – 5 years

13.0 Termination

- 13.1 The employer's certification shall be deemed revoked when employment is terminated.
- 13.2 A Level I, Level II, or Level III whose certification has been terminated may be certified 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:
 - 13.2.1 The employee has proof of prior certification.
 - 13.2.2 The employee was working in the capacity to which certified within six (6) months of termination.
 - 13.2.3 The employee is being recertified within six (6) months of termination.
 - 13.2.4 Prior to being examined for certification, employees not meeting above requirements should receive additional training as deemed appropriate by the Level III.

14.0 Reinstatement

- 14.1 A Level I, Level II, or Level III whose certification has been terminated may be reinstated to the former NDT level, without a new examination, provided all of the following conditions are met:
 - 14.1.1 The employer has maintained the personnel certification records required in section 9.4.
 - 14.1.2 The employee's certification did not expire during termination.
 - 14.1.3 The employee is being reinstated within six (6) months of termination.

Table 6.3.1 A Recommended Initial Training and Experience Levels

Examination Method	Level	Technique	High School graduate or equivalent	Completion with a passing grade of at least 2 years of engineering or science study at a university college or technical school	Minimum Required Work Experience in Method (Hours)	Permitted Time Frame (to obtain required work experience in method) (Months)
Acoustic Emission	I		40	32	210	1.5-9
	II		40	40	630	4.5-27
Electromagnetic	I		40	24	210	1.5-9
	II		40	40	630	4.5-27
Laser Methods	I	Profilometry	8	4	70	0.5-3
	II		24	12	140	1-6
	I	Holography/Shearography	40	36	210	1.5-9
	II		40	36	630	4.5-27
Leak Testing	I	Bubble Testing	2	2	3	4 hours to 3 days
	II		4	2	35	1 week to 6 weeks
	I	Pressure Change	24	16	105	0.75-4.5
	II		16	12	280	2-12
	I	Halogen Diode	12	8	105	0.75-4.5
	II		8	6	280	2-12
	I	Mass Spectrometer	40	28	280	2-12
	II		24	16	420	3-18
Liquid Penetrant	I		4	4	70	0.5-3
	II		8	4	140	1-6
Magnetic Particle	I		12	8	70	0.5-3
	II		8	4	210	1.5-9
Neutron Radiography	I		28	20	420	3-18
	II		40	40	1680	12-72
Radiography	I		40	30	210	1.5-9
	II		40	35	630	4.5-27
Thermal/Infrared	I		32	30	210	1.5-9
	II		34	32	1260	9-27
Ultrasonics	I		40	30	210	1.5-9
	II		40	40	840	4.5-27
Vibration Analysis	I		24	24	420	2-18
	II		72	48	1680	12-72
Visual	I		8	4	70	0.5-3
	II		16	8	140	1-6

Notes:

- 1.0 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 times required for Level I and Level II and the required training shall consist of the sum of the hours required for Level I and Level II.
- 2.0 For Level III certification, the required experience shall consist of the sum of the time required for Level I and Level II, and the additional requirements listed in 6.3.2. The required formal training shall consist of the Level I and Level II training, plus any additional formal training as defined in the employer's written practice.
- 3.0 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.
- 4.0 Training shall be outlined in the employer's written practice.

Table 6.3.1 B Alternate Initial Training and Experience Levels

Examination Method	Level	Technique	High School graduate or equivalent	Completion with a passing grade of at least 2 years of engineering or science study at a university college or technical school	Experience Level** (Months)
Acoustic Emission	I		40	32	3
	II		40	40	9
Electromagnetic	I		40	24	3
	II		40	40	9
Laser Methods	I	Profilometry	8	4	1
	II		24	12	2
	I	Holography/ Shearography	40	36	3
	II		40	36	9
Leak Testing	I	Bubble Testing	2	2	*
	II		4	2	0.5
	I	Pressure Change	24	16	1.5
	II		16	12	4
	I	Halogen Diode	12	8	1.5
	II		8	6	4
	I	Mass Spectrometer	40	28	4
	II		24	16	6
Liquid Penetrant	I		4	4	1
	II		8	4	2
Magnetic Particle	I		12	8	1
	II		8	4	3
Neutron Radiography	I		28	20	6
	II		40	40	24
Radiography	I		40	30	3
	II		40	35	9
Thermal/ Infrared	I		32	30	3
	II		34	32	18
Ultrasonics	I		40	30	3
	II		40	40	9
Vibration Analysis	I		24	24	6
	II		72	48	24
Visual	I		8	4	1
	II		16	8	2

* = 2 hours

** = Work Time Experience

Notes:

- 1.0 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 times required for Level I and Level II and the required training shall consist of the sum of the hours required for Level I and Level II.
- 2.0 For Level III certification, the required experience shall consist of the sum of the time required for Level I and Level II, and the additional requirements listed in 6.3.2. The required formal training shall consist of the Level I and Level II training, plus any additional formal training as defined in the employer's written practice.
- 3.0 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.
- 4.0 Initial experience may be gained simultaneously in two or more methods if the:
 - 4.1 candidate spends a minimum of 25 percent of work time on each method for which certification is sought, and
 - 4.2 remainder of the work time claimed as experience is spent in NDT-related activities defined in the employer's written practice.
- 5.0 Training shall be outlined in the employer's written practice.

RECOMMENDED TRAINING COURSES

Acoustic Emission Testing Method (Training Course Outline TC-8)

	Recommended Hours of Instruction	
	A*	B*
Level I		
Basic acoustic emission physics course	12	10
Basic acoustic emission technique course	28	22
Total	40	32
Level II		
Acoustic emission physics course	12	12
Acoustic emission technique course	28	28
Total	40	40

***A** High school graduate or equivalent.

***B** Completion with passing grades of at least two years of engineering or science study at a university, college or technical school.

This is a progressive training course. Consideration as Level I is based on satisfactory completion of the Level I training course. Consideration as Level II is based on satisfactory completion of both Level I and Level II training courses.

Topics in the training outline may be deleted or expanded to meet the employer's specific applications or for limited certification and may be accompanied by a corresponding change in training hours.

Recommended Training for Level I Acoustic Emission Testing

Basic Acoustic Emission Physics Course

1.0 Principles of Acoustic Emission Testing

- 1.1 Characteristics of acoustic emission
 - 1.1.1 Continuous emission
 - 1.1.2 Burst emission
 - 1.1.3 Emission/signal levels and frequencies
- 1.2 Sources of acoustic emission
 - 1.2.1 Sources in crystalline materials – introduction
 - 1.2.2 Sources in nonmetals – introduction
 - 1.2.3 Sources in composites – introduction
 - 1.2.4 Other sources
- 1.3 Wave propagation – introduction
 - 1.3.1 Wave velocity in materials
 - 1.3.2 Attenuation
 - 1.3.3 Reflections, multiple paths
 - 1.3.4 Source input versus signal output
- 1.4 Repeated loadings: Kaiser and Felicity effects and Felicity ratio
 - 1.4.1 In metals
 - 1.4.2 In composites
- 1.5 Terminology (refer to acoustic emission glossary, ASTM E1316)

2.0 Sensing the Acoustic Emission Wave

- 2.1 Sensors
 - 2.1.1 Principles of operation
 - 2.1.2 Construction
 - 2.1.3 Frequency
- 2.2 Sensor attachment
 - 2.2.1 Coupling materials
 - 2.2.2 Attachment devices

Total recommended hours of instruction for this course:

Classification A – 12 hours

Classification B – 10 hours

Basic Acoustic Emission Technique Course

1.0 Instrumentation and Signal Processing

- 1.1 Cables
 - 1.1.1 Coaxial cable
 - 1.1.2 Twisted pair cable
 - 1.1.3 Noise problems in cables
 - 1.1.4 Connectors
- 1.2 Signal conditioning
 - 1.2.1 Preamplifiers
 - 1.2.2 Amplifiers
 - 1.2.3 Filters
 - 1.2.4 Units of gain measurement
- 1.3 Signal detection

- 1.3.1 Threshold comparator
- 1.3.2 Units of threshold measurement
- 1.3.3 Sensitivity determined by gain and/or threshold
- 1.4 Signal processing
 - 1.4.1 Waveform characteristics
 - 1.4.2 Discrimination techniques
 - 1.4.3 Distribution techniques
- 1.5 Source location techniques
 - 1.5.1 Single channel location
 - 1.5.2 Linear location
 - 1.5.3 Planar location
 - 1.5.4 Other location techniques
- 1.6 Acoustic emission test systems
 - 1.6.1 Single channel systems
 - 1.6.2 Multichannel systems
 - 1.6.3 Dedicated industrial systems
- 1.7 Accessory techniques
 - 1.7.1 Audio indicators
 - 1.7.2 X-Y and strip chart recording
 - 1.7.3 Oscilloscopes
 - 1.7.4 Others

2.0 Acoustic Emission Test Techniques

- 2.1 Equipment calibration and setup for test
 - 2.1.1 Calibration signal generation techniques
 - 2.1.2 Calibration procedures
 - 2.1.3 Sensor placement
 - 2.1.4 Adjustment of equipment controls
 - 2.1.5 Discrimination technique adjustments
- 2.2 Loading procedures
 - 2.2.1 Type of loading
 - 2.2.2 Maximum test load
 - 2.2.3 Load holds
 - 2.2.4 Repeated and programmed loadings
 - 2.2.5 Rate of loading
- 2.3 Data display
 - 2.3.1 Selection of display mode
 - 2.3.2 Use and reading of different kinds of display
- 2.4 Noise sources and pre-test identification techniques
 - 2.4.1 Electromagnetic noise
 - 2.4.2 Mechanical noise
- 2.5 Precautions against noise
 - 2.5.1 Electrical shielding
 - 2.5.2 Electronic techniques
 - 2.5.3 Prevention of movement
 - 2.5.4 Attenuating materials and applications
- 2.6 Data interpretation and evaluation: introduction
 - 2.6.1 Separating relevant acoustic emission indications from noise
 - 2.6.2 Accept/reject techniques and evaluation criteria
- 2.7 Reports
 - 2.7.1 Purpose
 - 2.7.2 Content and structure

3.0 Codes, Standards and Procedures

- 3.1 Guidetype standards (glossaries, calibration, etc.)
- 3.2 Standardized/codified acoustic emission test procedures
- 3.3 User-developed test procedures

4.0 Applications of Acoustic Emission Testing (course should include at least 3 categories from 4.1 and at least 4 categories from 4.2)

- 4.1 Laboratory studies (material characterization)
 - 4.1.1 Crack growth and fracture mechanics
 - 4.1.2 Environmentally assisted cracking
 - 4.1.3 Dislocation movement (metals)
 - 4.1.4 Clarifying deformation mechanisms (composites)
 - 4.1.5 Phase transformation and phase stability
 - 4.1.6 Creep
 - 4.1.7 Residual stress
 - 4.1.8 Corrosion
 - 4.1.9 Fatigue
 - 4.1.10 Rupture
 - 4.1.11 Ductile/brittle transition
 - 4.1.12 Other material characterization applications
- 4.2 Structural applications
 - 4.2.1 Pressure vessels (metal)
 - 4.2.2 Storage tanks (metal)
 - 4.2.3 Pressure vessels/storage tanks (composite)
 - 4.2.4 Piping and pipelines
 - 4.2.5 Bucket trucks
 - 4.2.6 Aircraft
 - 4.2.7 Bridges
 - 4.2.8 Mines
 - 4.2.9 Dams, earthen slopes
 - 4.2.10 Pumps, valves, etc.
 - 4.2.11 Rotating plant
 - 4.2.12 In-process weld monitoring
 - 4.2.13 Leak detection and monitoring
 - 4.2.14 Other structural applications

Total recommended hours of instruction for this course:

Classification A – 28 hours

Classification B – 22 hours

Recommended Training for Level II Acoustic Emission Testing

Acoustic Emission Physics Course

1.0 Principles of Acoustic Emission Testing

- 1.1 Characteristics of acoustic emission testing
 - 1.1.1 Introductory concepts of source, propagation, measurement, display, evaluation
 - 1.1.2 Relationships between acoustic emission testing and other NDT methods
 - 1.1.3 Significance of applied load in acoustic emission testing
 - 1.1.4 Basic math review (exponents, graphing, metric units)
- 1.2 Materials and deformation
 - 1.2.1 Constitution of crystalline and noncrystalline materials
 - 1.2.2 Stress and strain
 - 1.2.3 Elastic and plastic deformation; crack growth
- 1.3 Sources of acoustic emission
 - 1.3.1 Burst emission, continuous emission
 - 1.3.2 Emission/signal levels, units of amplitude measurement

- 1.3.3 Sources in crystalline materials
 - 1.3.3.1 Dislocations – plastic deformation
 - 1.3.3.2 Phase transformations
 - 1.3.3.3 Deformation twinning
 - 1.3.3.4 Nonmetallic inclusions
 - 1.3.3.5 Subcritical crack growth
 - 1.3.3.5.1 Subcritical crack growth under increasing load
 - 1.3.3.5.2 Ductile tearing under increasing load
 - 1.3.3.5.3 Fatigue crack initiation and growth
 - 1.3.3.5.4 Hydrogen embrittlement cracking
 - 1.3.3.5.5 Stress corrosion cracking
- 1.3.4 Sources in nonmetals
 - 1.3.4.1. Microcracking
 - 1.3.4.2 Gross cracking
 - 1.3.4.3 Crazeing
 - 1.3.4.4 Other sources in nonmetals
- 1.3.5 Sources in composites
 - 1.3.5.1 Fiber breakage
 - 1.3.5.2 Matrix cracking
 - 1.3.5.3 Fiber-matrix debonding
 - 1.3.5.4 Delamination
 - 1.3.5.5 Fiber pull-out, relaxation
 - 1.3.5.6 Friction
- 1.3.6 Other sources
 - 1.3.6.1 Pressure leaks
 - 1.3.6.2 Oxide and scale cracking
 - 1.3.6.3 Slag cracking
 - 1.3.6.4 Frictional sources
 - 1.3.6.5 Liquefaction and solidification
 - 1.3.6.6 Loose parts, intermittent contact
 - 1.3.6.7 Fluids and nonsolids
 - 1.3.6.8 Crack closure
- 1.4 Wave propagation
 - 1.4.1 Near-field impulse response
 - 1.4.2 Modes of propagation
 - 1.4.3 Mode conversion, reflection and refraction
 - 1.4.4 Wave velocity in material
 - 1.4.5 Anisotropic propagation in composites
 - 1.4.6 Specimen geometry effects
- 1.5 Attenuation
 - 1.5.1 Geometric attenuation
 - 1.5.2 Dispersion
 - 1.5.3 Scattering, diffraction
 - 1.5.4 Attenuation due to energy loss mechanisms
 - 1.5.5 Attenuation versus frequency
- 1.6 Kaiser and Felicity effects, and Felicity Ratio
 - 1.6.1 In metals
 - 1.6.2 In composites
 - 1.6.3 In other materials
- 1.7 Terminology (refer to acoustic emission glossary, ASTM E1316)

2.0 Sensing the Acoustic Emission Wave

- 2.1 Transducing processes (piezoelectricity, etc.)
- 2.2 Sensors
 - 2.2.1 Construction
 - 2.2.2 Conversion efficiencies
 - 2.2.3 Calibration (sensitivity curve)

- 2.3 Sensor attachment
 - 2.3.1 Coupling materials
 - 2.3.2 Attachment devices
 - 2.3.3 Waveguides
- 2.4 Sensor utilization
 - 2.4.1 Flat response sensors
 - 2.4.2 Resonant response sensors
 - 2.4.3 Integral-electronics sensors
 - 2.4.4 Special sensors (directional, mode responsive)
 - 2.4.5 Sensor selection

Total recommended hours of instruction for this course:

Classification A – 12 hours

Classification B – 12 hours

Acoustic Emission Technique Course

1.0 Instrumentation and Signal Processing

- 1.1 Cables
 - 1.1.1 Coaxial cable
 - 1.1.2 Twisted pair cable
 - 1.1.3 Optical fiber cable
 - 1.1.4 Noise problems in cables
 - 1.1.5 Impedance matching
 - 1.1.6 Connectors
- 1.2 Signal conditioning
 - 1.2.1 Preamplifiers
 - 1.2.2 Amplifiers
 - 1.2.3 Filters
 - 1.2.4 Units of gain measurement
- 1.3 Signal detection
 - 1.3.1 Threshold comparator
 - 1.3.2 Units of threshold measurement
 - 1.3.3 Sensitivity determined by gain and/or threshold
- 1.4 Signal processing
 - 1.4.1 Waveform characteristics
 - 1.4.1.1 Amplitude analysis
 - 1.4.1.2 Pulse duration analysis
 - 1.4.1.3 Rise time analysis
 - 1.4.1.4 Event and event rate processing
 - 1.4.1.5 MARSE
 - 1.4.2 Discrimination techniques
 - 1.4.3 Distribution techniques
- 1.5 Source location techniques
 - 1.5.1 Single channel location
 - 1.5.2 Linear location
 - 1.5.3 Planar location
 - 1.5.4 Other location techniques
- 1.6 Acoustic emission test systems
 - 1.6.1 Single channel systems
 - 1.6.2 Multichannel systems
 - 1.6.3 Dedicated industrial systems
- 1.7 Accessory techniques
 - 1.7.1 Audio indicators
 - 1.7.2 X-Y and strip chart recording

- 1.7.3 Oscilloscopes
- 1.7.4 Magnetic recorders
- 1.7.5 Others
- 1.8 Advanced signal processing techniques
 - 1.8.1 Signal definition
 - 1.8.2 Signal capture
 - 1.8.3 Frequency analysis
 - 1.8.4 Pattern recognition

2.0 Acoustic Emission Test Techniques

- 2.1 Factors affecting test equipment selection
 - 2.1.1 Material being monitored
 - 2.1.2 Location and nature of emission
 - 2.1.3 Type of information desired
 - 2.1.4 Size and shape of test part
- 2.2 Equipment calibration and set up for test
 - 2.2.1 Calibration signal generation techniques
 - 2.2.2 Calibration procedures
 - 2.2.3 Sensor selection and placement
 - 2.2.4 Adjustment of equipment controls
 - 2.2.5 Discrimination technique adjustments
- 2.3 Loading procedures
 - 2.3.1 Type of loading
 - 2.3.2 Maximum test load
 - 2.3.3 Load holds
 - 2.3.4 Repeated and programmed loadings
 - 2.3.5 Rate of loading
- 2.4 Special test procedures
 - 2.4.1 High temperature/low temperature tests
 - 2.4.2 Interrupted tests (including cyclic fatigue)
 - 2.4.3 Long-term tests
 - 2.4.4 Tests in high noise environments
- 2.5 Data display
 - 2.5.1 Selection of display mode
 - 2.5.2 Use and reading of different kinds of display
- 2.6 Noise sources and pre-test identification techniques
 - 2.6.1 Electromagnetic noise
 - 2.6.2 Mechanical noise
- 2.7 Precautions against noise
 - 2.7.1 Electrical shielding
 - 2.7.2 Electronic techniques
 - 2.7.3 Prevention of movement
 - 2.7.4 Attenuating materials and applications
- 2.8 Data interpretation
 - 2.8.1 Recognizing noise in the recorded data
 - 2.8.2 Noise elimination by data filtering techniques
 - 2.8.3 Relevant and nonrelevant acoustic emission response
- 2.9 Data evaluation
 - 2.9.1 Methods for ranking, grading, accepting/rejecting
 - 2.9.2 Comparison with calibration signals
 - 2.9.3 Source evaluation by complementary NDT methods
- 2.10 Reports
 - 2.10.1 Purpose
 - 2.10.2 Content and structure

3.0 Codes, Standards, Procedures and Societies

- 3.1 Guidetype standards (glossaries, calibration, etc.
- 3.2 Standardized/codified acoustic emission test procedures
- 3.3 User-developed test procedures
- 3.4 Societies active in acoustic emission testing

4.0 Applications of Acoustic Emission Testing (course should include at least 3 categories from 4.1 and at least 4 categories from 4.2)

- 4.1 Laboratory studies (material characterization)
 - 4.1.1 Crack growth and fracture mechanics
 - 4.1.2 Environmentally assisted cracking
 - 4.1.3 Dislocation movement (metals)
 - 4.1.4 Clarifying deformation mechanisms (composites)
 - 4.1.5 Phase transformation and phase stability
 - 4.1.6 Creep
 - 4.1.7 Residual stress
 - 4.1.8 Corrosion
 - 4.1.9 Fatigue
 - 4.1.10 Rupture
 - 4.1.11 Ductile/brittle transition
 - 4.1.12 Other material characterization applications
- 4.2 Structural applications
 - 4.2.1 Pressure vessels (metal)
 - 4.2.2 Storage tanks (metal)
 - 4.2.3 Pressure vessels/storage tanks (composite)
 - 4.2.4 Piping and pipelines
 - 4.2.5 Bucket trucks
 - 4.2.6 Aircraft
 - 4.2.7 Bridges
 - 4.2.8 Mines
 - 4.2.9 Dams, earthen slopes
 - 4.2.10 Pumps, valves, etc.
 - 4.2.11 Rotating plant
 - 4.2.12 In-process weld monitoring
 - 4.2.13 Leak detection and monitoring
 - 4.2.14 Other structural applications

Total recommended hours of instruction for this course

Classification A – 28 hours

Classification B – 28 hours

Acoustic Emission Testing Method Level III Topical Outline

1.0 Principles and Theory

- 1.1 Characteristics of acoustic emission testing
 - 1.1.1 Concepts of source, propagation, loading, measurement, display, evaluation
 - 1.1.2 Proper selection of acoustic emission as technique of choice
 - 1.1.2.1 Differences between acoustic emission testing and other techniques
 - 1.1.2.2 Complementary roles of acoustic emission and other methods
 - 1.1.2.3 Potential or conflicting results between methods
 - 1.1.2.4 Factors that qualify/disqualify the use of acoustic emission testing
 - 1.1.3 Math review (exponents, logarithms, metric units and conversions)
- 1.2 Materials and deformation
 - 1.2.1 Materials constitution

- 1.2.1.1 Crystalline/noncrystalline
 - 1.2.1.2 Isotropic/anisotropic
 - 1.2.1.3 Metals/composites/other
 - 1.2.2 Stress and strain (including triaxial, residual, thermal)
 - 1.2.3 Elastic and plastic deformation; crack growth
 - 1.2.4 Materials properties (strength, toughness, etc.)
- 1.3 Sources of acoustic emission
 - 1.3.1 Broadband nature of source spectra
 - 1.3.2 Emission/signal levels, units of amplitude measurement
 - 1.3.3 Sources in crystalline materials
 - 1.3.3.1 Dislocations – plastic deformation
 - 1.3.3.2 Phase transformations
 - 1.3.3.3 Deformation twinning
 - 1.3.3.4 Nonmetallic inclusions
 - 1.3.3.5 Subcritical crack growth
 - 1.3.3.5.1 Subcritical crack growth under increasing load
 - 1.3.3.5.2 Ductile tearing under increasing load
 - 1.3.3.5.3 Fatigue crack initiation and growth
 - 1.3.3.5.4 Hydrogen embrittlement cracking
 - 1.3.3.5.5 Stress corrosion cracking
 - 1.3.4 Sources in nonmetals
 - 1.3.4.1 Microcracking
 - 1.3.4.2 Gross cracking
 - 1.3.4.3 Crazeing
 - 1.3.4.4 Other sources in nonmetals
 - 1.3.5 Sources in composites
 - 1.3.5.1 Fiber breakage
 - 1.3.5.2 Matrix cracking
 - 1.3.5.3 Fiber-matrix debonding
 - 1.3.5.4 Delamination
 - 1.3.5.5 Fiber pull-out, relaxation
 - 1.3.5.6 Friction
 - 1.3.6 Other sources
 - 1.3.6.1 Pressure leaks; cavitation
 - 1.3.6.2 Oxide and scale cracking
 - 1.3.6.3 Slag cracking
 - 1.3.6.4 Frictional sources
 - 1.3.6.5 Liquefaction and solidification
 - 1.3.6.6 Loose parts, intermittent contact
 - 1.3.6.7 Fluids and nonsolids
 - 1.3.6.8 Crack closure
 - 1.3.6.9 Corrosion
- 1.4 Wave propagation
 - 1.4.1 Near-field impulse response
 - 1.4.2 Modes of propagation (including Lamb waves)
 - 1.4.3 Mode conversion, reflection and refraction
 - 1.4.4 Wave velocity in material (including velocity dispersion)
 - 1.4.5 Anisotropic propagation in composites
 - 1.4.6 Specimen geometry effects
- 1.5 Attenuation
 - 1.5.1 Geometric attenuation
 - 1.5.2 Dispersion
 - 1.5.3 Scattering, diffraction
 - 1.5.4 Effects of contained fluids
 - 1.5.5 Attenuation due to energy loss mechanisms
 - 1.5.6 Attenuation versus frequency
- 1.6 Kaiser and Felicity effects, and Felicity ratio

- 1.6.1 In metals
- 1.6.2 In composites
- 1.6.3 Emission during load holds
- 1.7 Terminology (refer to acoustic emission glossary, ASTM 1316)

2.0 Equipment and Materials

- 2.1 Transducing processes (piezoelectricity, etc.)
- 2.2 Sensors
 - 2.2.1 Construction
 - 2.2.1.1 Single ended
 - 2.2.1.2 Differential
 - 2.2.1.3 Test environment considerations
 - 2.2.1.4 Wave mode sensitivity
 - 2.2.2 Conversion efficiencies; temperature effects
 - 2.2.3 Calibration
 - 2.2.3.1 Methods and significance
 - 2.2.3.2 Calculations from absolute sensitivity curve
 - 2.2.4 Reciprocity
- 2.3 Sensor attachment
 - 2.3.1 Coupling materials: selection and effective use
 - 2.3.2 Attachment devices
 - 2.3.3 Waveguides: design considerations, effect on signal
- 2.4 Sensor utilization
 - 2.4.1 Flat response sensors
 - 2.4.2 Resonant response sensors
 - 2.4.3 Integral-electronics sensors
 - 2.4.4 Special sensors (directional, mode responsive, accelerometers)
 - 2.4.5 Sensor selection
- 2.5 Simulated acoustic emission sources
 - 2.5.1 Hsu-Nielsen Source (lead break)
 - 2.5.2 Piezoelectric transducers and associated electronics
 - 2.5.3 Gas jet
 - 2.5.4 Other devices
- 2.6 Cables
 - 2.6.1 Cable types
 - 2.6.1.1 Coaxial
 - 2.6.1.2 Twisted pair
 - 2.6.1.3 Multiscreened
 - 2.6.1.4 Optical
 - 2.6.1.5 Others
 - 2.6.2 Shielding and other factors governing cable selection
 - 2.6.3 Cable length effects
 - 2.6.4 Noise problems in cables
 - 2.6.5 Cables as transmission lines
 - 2.6.6 Impedance matching
 - 2.6.7 Connectors
- 2.7 Signal conditioning
 - 2.7.1 Preamplifiers (dynamic range, cable drive capability, etc.)
 - 2.7.2 Amplifiers
 - 2.7.3 Filters: selection, roll-off rates
 - 2.7.4 Units of gain measurement
 - 2.7.5 Electronic noise
- 2.8 Signal detection
 - 2.8.1 Threshold comparator
 - 2.8.2 Units of threshold measurement
 - 2.8.3 Sensitivity determined by gain and/or threshold

- 2.8.4 Use of floating threshold
- 2.8.5 Dead time
- 2.9 Signal processing
 - 2.9.1 Waveform characteristics
 - 2.9.1.1 Amplitude
 - 2.9.1.2 Pulse duration
 - 2.9.1.3 Rise time
 - 2.9.1.4 Signal strength (MARSE)
 - 2.9.1.5 Threshold crossing counts
 - 2.9.1.6 Hit versus event processing
- 2.10 Source location
 - 2.10.1 Single channel location
 - 2.10.2 Linear location
 - 2.10.3 Planar location
 - 2.10.4 Hit-sequence zonal location
 - 2.10.5 Other location methods
 - 2.10.6 Guard channels and spatial filtering
- 2.11 Advanced signal processing
 - 2.11.1 Data filtering
 - 2.11.2 Signal definition
 - 2.11.3 Signal capture
 - 2.11.4 Frequency analysis (Fourier theorem, theory of spectrum)
 - 2.11.5 Pattern recognition
 - 2.11.6 Source function determination by deconvolution/Green's function
- 2.12 Acoustic emission test systems
 - 2.12.1 Single channel systems
 - 2.12.2 Multichannel systems
 - 2.12.3 Dedicated industrial systems
 - 2.12.4 Interpreting and writing system specifications
- 2.13 Accessory materials
 - 2.13.1 Audio indicators
 - 2.13.2 X-Y and strip chart recording
 - 2.13.3 Oscilloscopes
 - 2.13.4 Magnetic recorders
 - 2.13.5 Computers and their use
 - 2.13.5.1 Operating systems
 - 2.13.5.2 Data storage and transfer
 - 2.13.5.3 Data output
 - 2.13.6 Others
- 2.14 Factors affecting test equipment selection
 - 2.14.1 Material being monitored
 - 2.14.2 Location and nature of emission
 - 2.14.3 Type of information desired
 - 2.14.4 Size and shape of test part

3.0 Techniques

- 3.1 Equipment calibration and set up for test
 - 3.1.1 Calibration signal generation techniques
 - 3.1.2 Calibration procedures
 - 3.1.3 Sensor selection and placement
 - 3.1.4 Adjustment of equipment controls
 - 3.1.5 Discrimination technique adjustments
- 3.2 Establishing loading procedures
 - 3.2.1 Type of loading
 - 3.2.2 Maximum test load
 - 3.2.3 Load holds

- 3.2.4 Repeated and programmed loadings
- 3.2.5 Rate of loading
- 3.3 Precautions against noise
 - 3.3.1 Noise identification
 - 3.3.1.1 Electromagnetic noise
 - 3.3.1.2 Mechanical noise
 - 3.3.2 Noise elimination/discrimination before test
 - 3.3.2.1 Electrical shielding
 - 3.3.2.2 Grounding
 - 3.3.2.3 Frequency filtering
 - 3.3.2.4 Gain and/or threshold adjustment
 - 3.3.2.5 Floating threshold
 - 3.3.2.6 Attenuating materials and applications
 - 3.3.2.7 Prevention of movement, friction
 - 3.3.2.8 Guard channels, spatial filtering
 - 3.3.2.9 Timebased and loadbased gating
 - 3.3.2.10 Discrimination based on waveform characteristics
- 3.4 Special test procedures
 - 3.4.1 High temperature/low temperature tests
 - 3.4.2 Interrupted tests (including cyclic fatigue)
 - 3.4.3 Long-term tests, permanent/continuous monitoring
 - 3.4.4 Tests in high noise environments
- 3.5 Data displays
 - 3.5.1 Purpose and value of different displays
 - 3.5.1.1 Timebased and loadbased plots
 - 3.5.1.2 Location displays
 - 3.5.1.3 Distribution functions
 - 3.5.1.4 Crossplots
 - 3.5.1.5 Other displays
 - 3.5.2 Selection of displays

4.0 Interpretation and Evaluation

- 4.1 Data interpretation
 - 4.1.1 Relevant and nonrelevant acoustic emission response
 - 4.1.2 Recognizing noise versus true acoustic emission in the recorded data
 - 4.1.3 Distribution function analysis
 - 4.1.4 Crossplot analysis
 - 4.1.5 Noise elimination – data filtering techniques
 - 4.1.5.1 Spatial filtering
 - 4.1.5.2 Filtering on waveform characteristics
 - 4.1.5.3 Timebased and parametricbased filtering
- 4.2 Data evaluation
 - 4.2.1 Methods for ranking, grading, accepting/rejecting
 - 4.2.2 Comparison with calibration signals
 - 4.2.3 Source evaluation by complementary NDT methods
- 4.3 Reports
 - 4.3.1 Purpose
 - 4.3.2 Content and structure
 - 4.3.3 Developing a standard report format

5.0 Procedures

- 5.1 Guidetype standards (glossaries, calibration, etc.)
- 5.2 Standardized/codified acoustic emission test procedures
- 5.3 User-developed test procedures
- 5.4 Societies active in acoustic emission
- 5.5 Interpretation of codes, standards and procedures

- 5.6 Developing and writing acoustic emission test procedures
- 5.7 Training and examining Level I and II NDT personnel
- 6.0 Safety and Health**
 - 6.1 Hazards associated with structural failure during test
 - 6.2 Other hazards associated with acoustic emission testing
 - 6.3 Importance of local regulations
- 7.0 Applications**
 - 7.1 Laboratory studies (material characterization)
 - 7.1.1 Crack growth and fracture mechanics
 - 7.1.2 Environmentally assisted cracking
 - 7.1.3 Dislocation movement (metals) (strain rate and volume effects)
 - 7.1.4 Clarifying deformation mechanisms (composites)
 - 7.1.5 Phase transformation and phase stability
 - 7.1.6 Creep
 - 7.1.7 Residual stress
 - 7.1.8 Corrosion
 - 7.1.9 Fatigue
 - 7.1.10 Rupture
 - 7.1.11 Ductile/brittle transition
 - 7.1.12 Other material characterization applications
 - 7.2 Structural applications
 - 7.2.1 Pressure vessels (metal)
 - 7.2.2 Storage tanks (metal)
 - 7.2.3 Pressure vessels/storage tanks (composite)
 - 7.2.4 Piping and pipelines
 - 7.2.5 Bucket trucks
 - 7.2.6 Aircraft
 - 7.2.7 Bridges
 - 7.2.8 Mines
 - 7.2.9 Dams, earthen slopes
 - 7.2.10 Pumps, valves, etc.
 - 7.2.11 Rotating plant
 - 7.2.12 In-process weld monitoring
 - 7.2.13 Leak detection and monitoring
 - 7.2.14 Other structural applications

Recommended Training References

- Annual Book of ASTM Standards*, Volume 03.03, *Nondestructive Testing*. Philadelphia, PA: American Society for Testing and Materials. Latest edition.*
- Bingham, Ek and Tanner, eds. *Acoustic Emission Testing of Aerial Devices and Associated Equipment used in the Utility Industries* - STP 1139. Philadelphia, PA: American Society for Testing and Materials, 1992.
- Boiler and Pressure Vessel Code*, Section V. Articles 11 and 12. New York, NY: American Society of Mechanical Engineers. Latest edition.
- Drouillard, T. F. *Acoustic Emission: A Bibliography with Abstracts*. New York: Plenum Press, 1978.
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Nondestructive Evaluation and Quality Control: Metals Handbook, Vol. 17, ninth edition, Metals Park, OH: ASM International, 1989.*

Sachse, W., K. Yamaguchi and J. Roget, eds. *Acoustic Emission; Current Practice and Future Directions – STP 1077*, Philadelphia, PA: American Society for Testing and Materials, 1991.*

Spanner, J. C. *Acoustic Emission: Techniques and Applications*. Evanston, IL: Intex Publishing Co., 1974.*

Spanner, J. C., and J. W. McElroy, eds. *Monitoring Structural Integrity by Acoustic Emission B STP 571*. Philadelphia, PA: American Society for Testing and Materials, 1975.

Supplement to Recommended Practice No. SNT-TC-1A (Q&A Book); Acoustic Emission Testing Method, Columbus, OH: The American Society for Nondestructive Testing, Inc., 1995.*

* Available from the American Society for Nondestructive Testing, Columbus, Ohio.

Electromagnetic Testing Methods

(Training Course Outline TC-5)

		Recommended Hours of Instruction	
		A*	B*
Level I			
Basic electromagnetic physics course		24	12
Basic electromagnetic technique course		16	12
Total		40	24
 Level II			
Electromagnetic evaluation course			
Total		40	40

***A** High school graduate or equivalent.

***B** Completion with passing grades of at least two years of engineering or science study at a university, college or technical school.

This is a progressive training course. Consideration as Level I is based on satisfactory completion of the Level I training course. Consideration as Level II is based on satisfactory completion of both Level I and Level II training courses.

Topics in the training outline may be deleted or expanded to meet the employer's specific applications or for limited certification and may be accompanied by a corresponding change in training hours.

Recommended Training for Level I Electromagnetic Testing

Basic Electromagnetic Physics Course

1.0 Introduction to Electromagnetic Testing (Eddy Current/Flux Leakage)

- 1.1 Brief history of testing
- 1.2 Basic principles of testing

2.0 Electromagnetic Theory

- 2.1 Eddy current theory
 - 2.1.1 Generation of eddy currents by means of an alternating current field
 - 2.1.2 Effect of fields created by eddy currents (impedance changes)
 - 2.1.3 Effect of change of impedance on instrumentation
 - 2.1.4 Properties of eddy current
 - 2.1.4.1 Travel in circular direction
 - 2.1.4.2 Strongest on surface of test material
 - 2.1.4.3 Zero value at center of solid conductor placed in an alternating magnetic field
 - 2.1.4.4 Strength, time relationship and orientation as functions of test-system parameters and test-part characteristics
 - 2.1.4.5 Have properties of compressible fluids
 - 2.1.4.6 Small magnitude of current flow
 - 2.1.4.7 Relationship of frequency and plane with current in coil
 - 2.1.4.8 Effective permeability variations when induced in magnetic materials
 - 2.1.4.9 Effect of discontinuity orientation
 - 2.1.4.10 Power losses
- 2.2 Flux leakage theory
 - 2.2.1 Terminology and units
 - 2.2.2 Principles of magnetization
 - 2.2.2.1 B-H curve
 - 2.2.2.2 Magnetic properties
 - 2.2.2.3 Magnetic field
 - 2.2.2.4 Hysteresis loop
 - 2.2.2.5 Magnetic permeability
 - 2.2.2.6 Factors affecting permeability
 - 2.2.3 Magnetization B electromagnetism theory
 - 2.2.3.1 Oersted's law
 - 2.2.3.2 Faraday's law
 - 2.2.3.3 Electromagnetic
 - 2.2.4 Flux leakage theory and principle
 - 2.2.4.1 Residual
 - 2.2.4.2 Active
 - 2.2.4.3 Tangential leakage
 - 2.2.4.4 Normal leakage fields

Total recommended hours of instruction for this course:

Classification A – 24 hours

Classification B – 12 hours

Electromagnetic Technique Course

1.0 Readout Mechanism

- 1.1 Calibrated or uncalibrated meter
- 1.2 Null meter with dial indicator
- 1.3 Oscilloscope and other monitor displays
- 1.4 Alarm, lights, etc.
- 1.5 Numerical counters
- 1.6 Marking system
- 1.7 Sorting gates and tables
- 1.8 Cutoff saw or shears
- 1.9 Automation and feedback
- 1.10 Strip chart recorder

2.0 Types of Eddy Current Sensing Elements

- 2.1 Probes
 - 2.1.1 Types of arrangements
 - 2.1.1.1 Absolute
 - 2.1.1.2 Differential
 - 2.1.2 Lift-off
 - 2.1.3 Theory of operation
 - 2.1.4 Applications
 - 2.1.5 Advantages
 - 2.1.6 Limitations
- 2.2 Through, encircling or annular coils
 - 2.2.1 Types of arrangements
 - 2.2.1.1 Absolute
 - 2.2.1.2 Differential
 - 2.2.2 Fill factor
 - 2.2.3 Theory of operation
 - 2.2.4 Applications
 - 2.2.5 Advantages
 - 2.2.6 Limitations
- 2.3 Factors affecting choice of sensing elements
 - 2.3.1 Type of part to be inspected
 - 2.3.2 Type of discontinuity to be detected
 - 2.3.3 Speed of testing required
 - 2.3.4 Amount of testing (percentage) required
 - 2.3.5 Probable location of discontinuity

3.0 Types of Flux Leakage Sensing Elements

- 3.1 Principles of magnetic-measurement techniques
- 3.2 Inductive-coil sensors
 - 3.2.1 Theory of electromotive force (emf) induced in coil
 - 3.2.2 Various constructions and designs of coils
 - 3.2.3 Coil parameters affecting the flux leakage response
 - 3.2.4 Sensing-coil systems and connections (single- and multi-element probes)
- 3.3 Semiconductor sensing elements
 - 3.3.1 Hall-effect probes
 - 3.3.2 Magnetoresistors
 - 3.3.3 Magnetodiodes
 - 3.3.4 Magnetotransistors
 - 3.3.5 Magnetic and electric characteristics of semiconductor sensing elements
- 3.4 Other methods of magnetic leakage field detection
 - 3.4.1 Magnetic tape system

- 3.4.2 Magnetic powder
- 3.4.3 Magnetic-resonance sensor

Total recommended hours of instruction for this course:

Classification A –16 hours

Classification B –12 hours

Recommended Training for Level II Electromagnetic Testing

Electromagnetic Evaluation Course

1.0 Review of Electromagnetic Theory

- 1.1 Eddy current theory
- 1.2 Flux leakage theory
- 1.3 Types of eddy current sensing probes
- 1.4 Types of flux leakage sensing probes

2.0 Factors That Affect Coil Impedance

- 2.1 Test part
 - 2.1.1 Conductivity
 - 2.1.2 Permeability
 - 2.1.3 Mass
 - 2.1.4 Homogeneity
- 2.2 Test system
 - 2.2.1 Frequency
 - 2.2.2 Coupling
 - 2.2.3 Field strength
 - 2.2.4 Test coil and shape

3.0 Factors That Affect Flux Leakage Fields

- 3.1 Degree of magnetization
- 3.2 Defect geometry
- 3.3 Defect location
- 3.4 Defect orientation
- 3.5 Velocity factor
- 3.6 Distance between adjacent defects

4.0 Signal-to-Noise Ratio

- 4.1 Definition
- 4.2 Relationship to eddy current testing
- 4.3 Relationship to flux leakage testing
- 4.4 Methods of improving signal-to-noise ratio

5.0 Selection of Test Frequency

- 5.1 Relationship of frequency to type of test
- 5.2 Considerations affecting choice of test
 - 5.2.1 Signal-to-noise ratio
 - 5.2.2 Phase discrimination
 - 5.2.3 Response speed
 - 5.2.4 Skin effect

6.0 Selection of Method of Magnetization for Flux Leakage Testing

- 6.1 Magnetization characteristics for various magnetic materials
- 6.2 Magnetization by means of electric fields
 - 6.2.1 Circular field
 - 6.2.2 Longitudinal field
 - 6.2.3 Value of flux density
- 6.3 Magnetization by means of permanent magnets
 - 6.3.1 Permanent magnet relationship and theory
 - 6.3.2 Permanent magnet materials
- 6.4 Selection of proper magnetization method

7.0 Coupling

- 7.1 “Fill factor” in through-coil inspection
- 7.2 “Lift-off” and compensation in probe coil inspection
- 7.3 Flux leakage “fill factor” in flux leakage testing
- 7.4 “Lift-off” in flux leakage testing

8.0 Field Strength and its Selection

- 8.1 Permeability changes
- 8.2 Saturation
- 8.3 Effect of AC field strength on eddy current testing
- 8.4 Effect of field strength in flux leakage testing

9.0 Field Orientation for Flux Leakage Testing

- 9.1 Circular field
- 9.2 Longitudinal field

10.0 Instrument Design Considerations

- 10.1 Amplification
- 10.2 Phase detection
- 10.3 Differentiation of filtering

11.0 Applications

- 11.1 Flaw detection
 - 11.1.1 Eddy current methods
 - 11.1.2 Flux leakage methods
- 11.2 Sorting for properties related to conductivity B eddy current
- 11.3 Sorting for properties related to permeability
 - 11.3.1 Eddy current methods
 - 11.3.2 Flux leakage methods
- 11.4 Thickness evaluation B eddy current
- 11.5 Measurement of magnetic-characteristic values
 - 11.5.1 Eddy current methods
 - 11.5.2 Flux leakage methods

12.0 User Standards and Operating Procedures

- 12.1 Explanation of standards and specifications used in electromagnetic testing
- 12.2 Explanation of operating procedures used in electromagnetic testing

Total recommended hours of instruction for this course:

Classification A – 40 hours

Classification B – 40 hours

Electromagnetic Testing Method

Level III Topical Outline

1.0 Principles/Theory

- 1.1 Eddy Current Theory
 - 1.1.1 Generation of eddy currents
 - 1.1.2 Effect of fields created by eddy currents (impedance changes)
 - 1.1.3 Properties of eddy current
 - 1.1.3.1 Travel mode
 - 1.1.3.2 Depth of penetration
 - 1.1.3.3 Effects of test part characteristics
 - 1.1.3.4 Current flow
 - 1.1.3.5 Frequency and phase
 - 1.1.3.6 Effects of permeability variations
 - 1.1.3.7 Effects of discontinuity orientation

2.0 Equipment/Materials

- 2.1 Probes – general
 - 2.1.1 Advantages/Limitations
- 2.2 Through, encircling or annular coils
 - 2.2.1 Advantages/Limitations
- 2.3 Factors affecting choice of sensing elements
 - 2.3.1 Type of part to be inspected
 - 2.3.2 Type of discontinuity to be detected
 - 2.3.3 Speed of testing required
 - 2.3.4 Amount of testing required
 - 2.3.5 Probable location of discontinuity
 - 2.3.6 Applications other than discontinuity detection
- 2.4 Read out selection
 - 2.4.1 Meter
 - 2.4.2 Oscilloscope and other monitor displays
 - 2.4.3 Alarm, lights, etc.
 - 2.4.4 Strip chart recorder
- 2.5 Instrument design considerations
 - 2.5.1 Amplification
 - 2.5.2 Phase detection
 - 2.5.3 Differentiation or filtering

3.0 Techniques/Calibrations

- 3.1 Factors which affect coil impedance
 - 3.1.1 Test part
 - 3.1.2 Test system
- 3.2 Selection of test frequency
 - 3.2.1 Relation of frequency to type of test
 - 3.2.2 Consideration affecting choice of test
 - 3.2.2.1 Signal/noise ratio
 - 3.2.2.2 Phase discrimination
 - 3.2.2.3 Response speed
 - 3.2.2.4 Skin effect
- 3.3 Coupling
 - 3.3.1 Fill factor
 - 3.3.2 Lift off
- 3.4 Field strength
 - 3.4.1 Permeability changes
 - 3.4.2 Saturation
 - 3.4.3 Effect of AC field strength on eddy current testing

- 3.5 Comparison of techniques
- 3.6 Calibration
 - 3.6.1 Techniques
 - 3.6.2 Reference standards
- 3.7 Techniques – general
 - 3.7.1 Thickness gaging
 - 3.7.2 Sorting
 - 3.7.3 Conductivity
 - 3.7.4 Surface or subsurface flaw detection
 - 3.7.5 Tubing
 - 3.7.6 Remote field
- 4.0 Interpretation/Evaluation**
 - 4.1 Flaw detection
 - 4.2 Sorting for properties
 - 4.3 Thickness gaging
 - 4.4 Process control
 - 4.5 General interpretations
- 5.0 Procedures**

Recommended Training References

Electromagnetic Testing Method, Level I, II and III

- Annual Book of ASTM Standards*, Volume 03.03. *Nondestructive Testing*. Philadelphia, PA: American Society for Testing and Materials. Latest edition.*
- ASNT Level III Study Guide – Eddy Current Testing Method*. Columbus, OH: The American Society for Nondestructive Testing, Inc., 1983.*
- Cecco, V. S., G. Van Drunen, and F. L. Sharp. *Eddy Current Testing*. Columbia, MD: GP Courseware, 1987.*
- Eddy Current Testing, Classroom Training Handbook (CT-6-5)*. San Diego, CA: General Dynamics/Convair Division, 1979.†
- Eddy Current Testing, Programmed Instruction Handbook (PI-4-5)*. San Diego, CA: General Dynamics/Convair Division, 1980.†
- Libby, Hugo L. *Introduction to Electromagnetic Nondestructive Test Methods*. Huntington, NY: Robert E. Krieger Publishing Co., 1971.*
- McGonnagle, Warren J. *Nondestructive Testing*, second edition. New York: Gordon and Breach, 1975.*
- McMaster, Robert C., ed. *Nondestructive Testing Handbook*, first edition. Columbus, OH: The American Society for Nondestructive Testing, 1959.*
- Mester, M. L., and Paul McIntire, eds. *Nondestructive Testing Handbook: Electromagnetic Testing*, Vol. 4, second edition. Columbus, OH: The American Society for Nondestructive Testing, 1986.*
- Mix, Paul E. *Introduction to Nondestructive Testing: A Training Guide*. New York: John Wiley & Sons, 1987.*
- Radio Amateur's Handbook*. Neurington, CT: American Radio Relay League. Latest edition.
- Nondestructive Inspection and Quality Control: Metals Handbook*, Volume 11, eighth edition. Metals Park, OH: American Society for Metals, 1976.*
- Supplement to Recommended Practice No. SNT-TC-1A (Q&A Book): Eddy Current/Flux Leakage Testing Method*. Columbus, OH: The American Society for Nondestructive Testing, Inc., 1995.*

* Available from the American Society for Nondestructive Testing, Inc., Columbus, Ohio.

** This book is a Recommended Reference because of the valuable data it contains. This title is currently out of print, however, and is not available from ASNT.

† Currently published by the American Society for Nondestructive Testing, Inc., Columbus, Ohio.

Laser Testing Methods — Holography/Shearography (Training Course Outline TC-14)

	Recommended Hours of Instruction	
	A*	B*
Level I		
Basic holography/shearography physics course	10	8
Basic holography/shearography operating course	10	8
Basic holography/shearography application course	20	20
Total	40	36
Level II		
Intermediate holography/shearography physics course	10	8
Intermediate holography/shearography operating course	10	8
Intermediate holography/shearography application course	20	20
Total	40	36

***A** High school graduate or equivalent.

***B** Completion with passing grades of at least two years of engineering or science study at a university, college or technical school.

This is a progressive training course. Consideration as Level I is based on satisfactory completion of the Level I training course. Consideration as Level II is based on satisfactory completion of both Level I and Level II training courses.

Topics in the training outline may be deleted or expanded to meet the employer's specific applications or for limited certification and may be accompanied by a corresponding change in training hours.

Recommended Training for Level I Laser Method Fundamentals in Holography/Shearography Course

Basic Holography/Shearography Physics Course

Note: It is recommended that the trainee receive instruction in this course, which focuses on laser safety, prior to performing work in holography and shearography.

1.0 Introduction

- 1.1 Definition of speckle interferometry
- 1.2 History of holography and shearography testing
- 1.3 Applications of shearography NDT (SNDT)
- 1.4 Nondestructive testing
- 1.5 Responsibilities of levels of certification
- 1.6 Overview of shearography NDT

2.0 Basic Principles of Light and SNDT

- 2.1 Nature of light
- 2.1 Light as a wave
- 2.3 Definition of coherence
- 2.4 Speckles
- 2.5 Interference
- 2.6 Interferometry
- 2.7 Stress, the application of force
- 2.8 Strain, the resultant deformation
- 2.9 The double lobed fringe pattern

3.0 Lasers

- 3.1 Introduction to lasers
- 3.2 Laser light
- 3.3 Expanded coherent light as a measuring stick
- 3.4 Types of lasers
- 3.5 Ion lasers
- 3.6 Diode lasers

4.0 Laser Safety

- 4.1 Introduction
- 4.2 Do not stare into the beam
- 4.3 Classifications of laser systems
- 4.4 Nature of laser light
- 4.5 The expanded beam
- 4.6 Laser measurements for safety
- 4.7 Safe use of lasers
- 4.8 Laser safety officer
- 4.9 Safety requirements for the laboratory
- 4.10 Safety requirements for production
- 4.11 Safety requirements for the shop or field
- 4.12 Safe system design
- 4.13 Enclosures
- 4.14 Interlocks
- 4.15 Safety during maintenance
- 4.16 Keeping laser systems safe

5.0 Basic Holography/Shearography System

- 5.1. Laser illumination
- 5.2 Shearography camera
- 5.3 Image processor
- 5.4 Stressing methods

Total recommended hours of instruction for this course:

Classification A – 10 hours

Classification B – 8 hours

Recommended Training for Level I Holography/Shearography NDT

Basic Operating Course

1.0 Introduction

- 1.1 Laser holography/shearography NDT
- 1.2 Basic holography/shearography system
- 1.3 Setup and stability

2.0 Laser Safety Review

- 2.1 Do not stare into the beam
- 2.2 Classifications of laser systems
- 2.3 Safe use of lasers
- 2.4 Safe system design
- 2.5 Keeping laser systems safe

3.0 Laser Systems

- 3.1 Types of laser systems
- 3.2 Tuning an ion laser
- 3.3 Tuning a fiber optic cable (optional)
- 3.4 The simplicity of diode lasers
- 3.5 Aligning the illumination beam for the camera

4.0 Holography/Shearography Camera

- 4.1 Clarity (focus)
- 4.2 Iris settings
- 4.3 Shear optics and shear vector
- 4.4 Holography optics (in-plane and out-of-plane)
- 4.5 Phase stepping
- 4.6 Reflections
- 4.7 Illumination versus field of view

5.0 Holography/Shearography Image Processor

- 5.1 The video signal
- 5.2 Processing technique and parameters
- 5.3 Introduction to advanced processing techniques
- 5.4 Data storage and print out

6.0 Operation of the Image Processor

- 6.1 Basic system setup
- 6.2 SNTDT setup
- 6.3 Strain measurement setup

7.0 Primary Test Methods

- 7.1 Mechanical loading
- 7.2 Thermal stressing
- 7.3 Vacuum stressing (pressure reduction)
- 7.4 Pressurization stressing
- 7.5 Vibration excitation

8.0 Documentation

- 8.1 Introduction to documentation
- 8.2 Digital image file
- 8.3 Video printer
- 8.4 Video tape

9.0 Holography/Shearography Systems

- 9.1 Basic holography/shearography system
- 9.2 Production systems
- 9.3 Field inspection systems

Total recommended hours of instruction for this course:

Classification A – 10 hours

Classification B – 8 hours

Basic Application Course

1.0 Introduction

- 1.1 Overview
- 1.2 Test standards
- 1.3 Inspection documentation

2.0 Basic Fringe Interpretation

- 2.1 Fringe generation
- 2.2 Basic quantitative measurements with fringes
- 2.3 Indication types – true indications repeat
- 2.4 Shear orientation effect
- 2.5 Defect types
- 2.6 Defect measurements
- 2.7 Depth interpretation

3.0 Mechanical Loading

- 3.1 Types of loading
- 3.2 Applications
- 3.3 Interpretations of results

4.0 Thermal Stress

- 4.1 Types of stressing
 - 4.1.1 Heat then test
 - 4.1.2 Test and heat
 - 4.1.3 Time versus temperature
- 4.2 Applications
- 4.3 Interpretation of results

5.0 Vacuum Stress

- 5.1 Types of stressing
 - 5.1.1 Vacuum chamber
 - 5.1.2 Portable inspection head
 - 5.1.3 Depth versus fringes
- 5.2 Applications
- 5.3 Interpretation of results

6.0 Pressurization Stress

- 6.1 Types of stressing
- 6.2 Applications
- 6.3 Interpretation of results

7.0 Vibration Excitation, Mechanical

- 7.1 Types of excitation
 - 7.1.1 Frequency versus material
 - 7.1.2 Frequency versus defect size
 - 7.1.3 Amplitude
- 7.2 Applications
- 7.3 Interpretation of results

8.0 Vibration Excitation, Acoustic

- 8.1 Types of excitation
 - 8.1.1 Frequency versus material
 - 8.1.2 Frequency versus defect size
 - 8.1.3 Amplitude
- 8.2 Applications
- 8.3 Interpretation of results
- 8.4 Safe use of acoustic exciters

9.0 Complex structures

- 9.1 Types of constructions
- 9.2 Interpretation of results

Total recommended hours of instruction for this course:

Classification A – 20 hours

Classification B – 2 hours

Recommended Training for Level II Holography/Shearography NDT

Intermediate Physics Course

1.0 Physics of Light

- 1.1 Basic wave theory
- 1.2 Coherence and interference
- 1.3 Specular versus diffuse light
- 1.4 Holography optics (in-plane and out-of-plane)
- 1.5 Shearography optics

2.0 Physics of Lasers

- 2.1 Construction of ion lasers
- 2.2 Maintenance of ion lasers

- 2.3 Fiber optic beam delivery systems
- 2.4 Construction of DPY lasers
- 2.5 Logistics and choice of lasers

3.0 Laser Safety Officer

- 3.1 The guide to the safe use of lasers
- 3.2 Developing procedures

4.0 Physics of Materials

- 4.1 Stress/strain, the modulus of elasticity
- 4.2 Plate deformation equation
- 4.3 Deformation versus strain
- 4.4 Specular versus diffuse materials
- 4.5 Mechanical stress/strain
- 4.6 Thermal expansion of materials
- 4.7 Vacuum stress and out-of-plane strain
- 4.8 Pressure and hoop strain
- 4.9 Vibration and resonance
- 4.10 Stress relaxation

Total recommended hours of instruction for this course:

Classification A – 10 hours

Classification B – 8 hours

Intermediate Operating Course

1.0 Holography and Shearography Systems

- 1.1 Automated inspection stations
- 1.2 Tripodbased inspections
- 1.3 On vehicle inspections

2.0 Sources of Noise and Solutions

- 2.1 Stability
- 2.2 Vibration
- 2.3 Thermal gradients
- 2.4 Air currents

3.0 Fixturing

- 3.1 Simple forms
- 3.2 Automated system requirements

4.0 Speckle Interferometry Camera

- 4.1. Field of view (FOV) – zoom
- 4.2 Resolution versus FOV
- 4.3 Focus and iris settings
- 4.4 Sensitivity versus shear angle
- 4.5 Effects of shear orientation
- 4.6 Specular reflections

5.0 Speckle Interferometry Image Processor

- 5.1 Advanced processor adjustment
- 5.2 Advanced post processing techniques
- 5.3 Interface options
- 5.4 Documentation options

6.0 Stressing Systems Setup and Operation

- 6.1 Thermal stressing system
- 6.2 Vacuum inspection station
- 6.3 Pressurization stressing
- 6.4 Vibration excitation

7.0 Method Development

- 7.1 Test standards
- 7.0 Method format

8.0 Documentation

- 8.1 Digital image file management
- 8.2 Reporting
- 8.3 Video prints
- 8.4 Video tapes
- 8.5 Archiving data

Total recommended hours of instruction for this course:

Classification A – 10 hours

Classification B – 10 hours

Intermediate Applications Course

1.0 Materials and Applications

- 1.1 Laminates
- 1.2 Honeycombs
- 1.3 Foam core materials
- 1.4 Advanced materials
- 1.5 Pressure vessel, piping and tubing
- 1.5 Plasma spray and ceramics
- 1.6 Bonded metal

2.0 Fringe Interpretation

- 2.1 Quantitative fringe measurement
- 2.2 Defect measurement and characterization
- 2.3 Strain measurement

3.0 Mechanical Loading

- 3.1 Review of mechanical loading methods
- 3.2 Applications
 - 3.2.1 Cracks
 - 3.2.2 Material weaknesses
- 3.3 Interpretation of results

4.0 Thermal Stress

- 4.1 Review of thermal stressing methods
 - 4.1.1 Time versus Temperature
 - 4.1.2 Time versus depth
- 4.2 Applications
 - 4.2.1 Delamination
 - 4.2.2 Impact damage
 - 4.2.3 Composite repair evaluation
 - 4.2.4 Foreign material

4.3 Interpretation of results

5.0 Vacuum Stress

- 5.1 Review of vacuum stressing methods
 - 5.1.1 The general purpose method
 - 5.1.2 Depth versus fringes
- 5.2 Applications
 - 5.2.1 Near side disbonds
 - 5.2.1 Far side disbonds
 - 5.2.3. Composite repair evaluation
 - 5.2.4 Delaminations
- 5.3 Interpretation of results
 - 5.3.1 Effects of windows

6.0 Pressurization Stress

- 6.1 Review of pressure stressing methods
- 6.2 Applications
 - 6.2.1 Piping and tubing
 - 6.2.2 Pressure vessels
 - 6.2.3 Aircraft fuselage
- 6.3 Interpretation of results

7.0 Vibration Excitation, Mechanical

- 7.1 Review of mechanical vibration excitation methods
 - 7.1.1 Frequency versus material
 - 7.1.2 Frequency versus defect size
 - 7.1.3 Amplitude
 - 7.1.4 Sweep rate
 - 7.1.5 White noise
- 7.2 Applications
- 7.3 Interpretation of results

8.0 Vibration Excitation, Acoustic

- 8.1 Review of acoustic vibration excitation methods
 - 8.1.1 Frequency versus material
 - 8.1.2 Frequency versus defect size
 - 8.1.3 Amplitude
- 8.2 Applications
- 8.3 Interpretation of results
- 8.4 Safe use of acoustic exciters

9.0 Other Stressing Methods

- 9.1 Review of stress relaxation methods
- 9.2 Applications
- 9.3 Interpretation

Total recommended hours of instruction for this course:

Classification A – 20 hours

Classification B – 20 hours