

ASNT Standard

2011 Edition

Topical Outlines for Qualification of Nondestructive Testing Personnel



American National Standard
ASNT Standard Topical Outlines for
Qualification of Nondestructive Testing Personnel

Secretariat

The American Society for Nondestructive Testing, Inc.

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American National Standards Institute

Abstract

This standard applies to personnel whose specific tasks or jobs require appropriate knowledge of the technical principles underlying nondestructive testing (NDT) methods for which they have responsibilities within the scope of their employment. These specific tasks or jobs include, but are not limited to, performing, specifying, reviewing, monitoring, supervising, and evaluating NDT work.

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American National Standard

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ASNT Mission Statement:

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

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Foreword

(This foreword is not part of American National Standard CP-105-2011.)

An essential element in the effectiveness of nondestructive testing (NDT) is the qualification of the personnel who are responsible for and who perform nondestructive testing. Formal training is an important and necessary element in acquiring the skills necessary to effectively perform nondestructive tests.

The American Society for Nondestructive Testing, Inc. (ASNT) has, therefore, undertaken the preparation and publication of this standard which specifies the body of knowledge to be used as part of a training program qualifying and certifying NDT personnel.

The ASNT Standard Topical Outlines for Qualification of Nondestructive Testing Personnel (Document No. ASNT-CP-105) was initially processed and approved for submittal to the American National Standards Institute (ANSI) by the ASNT Standards Development Committee. This revision was processed by the ASNT Standards Development Committee. Committee approval of the standard does not necessarily imply that all committee members voted for its approval. At the time it approved this standard, the Standards Development Committee had the following members:

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ASNT Standard Topical Outlines for Qualification of Nondestructive Testing Personnel

1.0 Scope

- 1.1 This standard establishes the minimum topical outline requirements for the qualification of nondestructive testing (NDT) personnel.
- 1.2 This standard details the minimum training course content for NDT personnel.
- 1.3 The amount of time spent on each topic in each method should be determined by the NDT Level III and the applicable certification document.
- 1.4 These topical outlines are progressive; i.e., 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.
- 1.5 Topics in the outlines may be deleted or expanded to meet the employer's specific applications or for limited certification, unless stated otherwise by the applicable certification procedure or written practice.



Documents

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Acoustic Emission Testing Level I Topical Outline

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 AE Glossary, ASTM E 1316)
- 2.0 Sensing the AE 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

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 Multi-channel 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 Guide-type 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

Acoustic Emission Testing Level II Topical Outline

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 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 AE Glossary, ASTM E 1316)
- 2.0 Sensing the AE 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

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 Multi-channel 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 setup 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 Guide-type 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
- 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

Acoustic Emission Testing 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 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 E 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 AE 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
 - 2.10.4 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 Multi-channel 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 setup 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 Time-based and load-based 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 Time-based and load-based 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 AE response
 - 4.1.2 Recognizing noise versus true AE 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 Time-based and parametric-based 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 Guide-type standards (glossaries, calibration, etc.)
 - 5.2 Standardized/codified AE test procedures
 - 5.3 User-developed test procedures
 - 5.4 Societies active in AE
 - 5.5 Interpretation of codes, standards and procedures
 - 5.6 Developing and writing AE 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 AE 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

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Alternating Current Field Measurement Testing

Level I Topical Outline

Theory Course

- 1.0 Introduction to Electromagnetic Testing
 - 1.1 Brief history of testing
 - 1.2 Basic principles of NDT testing
- 2.0 Electromagnetic Theory
 - 2.1 Eddy current theory
 - 2.1.1 Generation of eddy currents by means of an AC field
 - 2.1.2 Effects of fields created by eddy currents
 - 2.1.3 Properties of eddy currents
 - 2.1.3.1 Travel in circular direction
 - 2.1.3.2 Eddy current distribution
 - 2.1.3.3 Effects of lift off and geometry
 - 2.1.3.4 Relationship of magnetic field in relation to a current in a coil

- 2.1.3.5 Effects of permeability variations in magnetic materials
 - 2.1.3.6 Effect of discontinuities
 - 2.1.3.7 Relationship between frequency and depth of penetration
 - 2.1.3.8 Standard depths of penetration
- 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 fields
 - 2.2.2.4 Magnetic permeability
 - 2.2.2.5 Factors affecting magnetic permeability
- 2.3 Basic electrical theory
 - 2.3.1 Basic units of electrical measurement
 - 2.3.2 Direct current circuits
 - 2.3.3 Ohm's law
 - 2.3.4 Faraday's law
 - 2.3.5 Resistance
 - 2.3.6 Inductance
 - 2.3.7 Magnetic effect of electrical currents

Technique Course

- 1.0 Alternating Current Field Measurement Theory
 - 1.1 Production of uniform fields
 - 1.2 Current flow, Bx, Bz and By relationships
 - 1.3 Relationship of the Bx, Bz and butterfly plots
 - 1.4 Other sources that influence the signals
- 2.0 Types of Probes
 - 2.1 Coil arrangements
 - 2.1.1 Primary induction coil
 - 2.1.2 Bx and By sensor coils
 - 2.2 Coil factors (lift off)
 - 2.3 Theory of operation
 - 2.4 Applications
 - 2.5 Limitations
 - 2.6 Probe markings
- 3.0 Probe Software
 - 3.1 Probe software versions and compatibility
 - 3.2 Manufacturers' sensitivity settings
 - 3.2.1 Gain
 - 3.2.2 Scalings
 - 3.2.3 Relationship between gain and current settings
 - 3.3 Sensitivity checks
- 4.0 Factors Affecting the Choice of Probes
 - 4.1 Type of part to be inspected
 - 4.2 Type of discontinuity to be inspected
 - 4.3 Speed of testing required
 - 4.4 Probable location of discontinuity
- 5.0 Types of Hardware and Operating Software Applications
 - 5.1 Choice of systems for specific applications
 - 5.2 Choice of software for specific applications

- 5.2.1 Depth and length sizing capabilities
- 5.2.2 Probe resolution
- 5.2.3 Coating thickness
- 6.0 Scanning for Detection
 - 6.1 Initial set up
 - 6.2 Setting position indicators
 - 6.3 Probe orientation
 - 6.4 Scanning speed
 - 6.5 Scanning pattern for tubulars and pipes
 - 6.6 Scanning pattern for linear sections
 - 6.7 Scanning for transverse cracks
- 7.0 Signal Interpretation
 - 7.1 Review of display format
 - 7.2 Detection and examination procedure
 - 7.3 Crack signals – linear cracks, angled cracks, line contacts and multiple cracks, transverse cracks
 - 7.4 Other signal sources – lift-off, geometry, materials, magnetism, edges and corners

Alternating Current Field Measurement Testing Level II

Topical Outline

Principles Course

- 1.0 Review of Electromagnetic Theory
 - 1.1 Eddy current theory
 - 1.2 Alternating current field measurement theory
 - 1.3 Types of alternating current field measurement sensing probes
- 2.0 Factors that Affect Depth of Penetration
 - 2.1 Conductivity
 - 2.2 Permeability
 - 2.3 Frequency
 - 2.4 Coil size
- 3.0 Factors that Affect Alternating Current Field Measurement Testing
 - 3.1 Residual fields
 - 3.2 Defect geometry
 - 3.3 Defect location: scanning pattern for attachments, corners and ratholes
 - 3.4 Defect orientation
 - 3.5 Distance between adjacent defects

Techniques and Applications Course

- 1.0 Software Commands
 - 1.1 Probe file production
 - 1.1.1 Selection of gain and frequency settings for specific applications
 - 1.1.2 Selection of current for specific applications
 - 1.1.3 Selections of sensitivity settings and scalings for specific applications
 - 1.2 Standardization settings
 - 1.2.1 Alarm settings
 - 1.2.2 Butterfly plot scalings
 - 1.3 Adjustment of communication rates

- 2.0 User Standards and Operating Procedures
 - 2.1 Explanation of standards applicable to alternating current field measurement testing
 - 2.2 Explanation of operating procedures applicable to alternating current field measurement testing

Eddy Current Testing Level I Topical Outline

Theory Course

- 1.0 Introduction to Eddy Current Testing
 - 1.1 Historical and developmental process
 - 1.1.1 Founding fathers: Arago, Lenz, Faraday, Maxwell
 - 1.1.2 Advances in electronics
 - 1.2 Basic physics and controlling principles
 - 1.2.1 Varying magnetic fields
 - 1.2.2 Electromagnetic induction
 - 1.2.3 Primary and secondary force relationships
- 2.0 Electromagnetic Theory
 - 2.1 Eddy current theory
 - 2.1.1 Generation of eddy currents by means of an AC 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 Small magnitude of current flow
 - 2.1.4.6 Relationships of frequency and phase
 - 2.1.4.7 Electrical effects, conductivity of materials
 - 2.1.4.8 Magnetic effects, permeability of materials
 - 2.1.4.9 Geometrical effects
- 3.0 Lab Demonstration
 - 3.1 Generation of Z-curves with conductivity samples
 - 3.2 Generation of lift-off curves

Basic Technique Course

- 1.0 Types of Eddy Current Sensing Elements
 - 1.1 Probes
 - 1.1.1 Types of arrangements
 - 1.1.1.1 Probe coils
 - 1.1.1.2 Encircling coils
 - 1.1.1.3 Inside coils
 - 1.1.2 Modes of operation
 - 1.1.2.1 Absolute
 - 1.1.2.2 Differential
 - 1.1.2.3 Hybrids
 - 1.1.3 Theory of operation
 - 1.1.4 Hall effect sensors
 - 1.1.4.1 Theory of operation
 - 1.1.4.2 Differences between coil and hall-element systems

- 1.1.5 Applications
 - 1.1.5.1 Measurement of material properties
 - 1.1.5.2 Flaw detection
 - 1.1.5.3 Geometrical features
- 1.1.6 Advantages
- 1.1.7 Limitations
- 1.2 Factors affecting choice of sensing elements
 - 1.2.1 Type of part to be inspected
 - 1.2.2 Type of discontinuity to be detected
 - 1.2.3 Speed of testing required
 - 1.2.4 Amount of testing (percentage) required
 - 1.2.5 Probable location of discontinuity
- 2.0 Selection of Inspection Parameters
 - 2.1 Frequency
 - 2.2 Coil drive: current/voltage
 - 2.3 Hall element drive: current/voltage
 - 2.4 Channel gain
 - 2.5 Display sensitivity selections
 - 2.6 Standardization
 - 2.7 Filtering
 - 2.8 Thresholds
- 3.0 Readout Mechanisms
 - 3.1 Calibrated or uncalibrated meters
 - 3.2 Impedance plane displays
 - 3.2.1 Analog
 - 3.2.2 Digital
 - 3.3 Data recording systems
 - 3.4 Alarms, lights, etc.
 - 3.5 Numerical readouts
 - 3.6 Marking systems
 - 3.7 Sorting gates and tables
 - 3.8 Cutoff saw or shears
 - 3.9 Automation and feedback
- 4.0 Lab Demonstration
 - 4.1 Demo filter effects on rotating reference standards
 - 4.2 Demo lift-off effects
 - 4.3 Demo frequency effects
 - 4.4 Demo rotational and forward speed effects
 - 4.5 Generate a Z-curve with conductivity standards

Eddy Current Testing Level II Topical Outline

Principles Course

- 1.0 Review of Electromagnetic Theory
 - 1.1 Eddy current theory
 - 1.2 Types of eddy current 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



Documents

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- 2.2 Test system
 - 2.2.1 Frequency
 - 2.2.2 Coupling
 - 2.2.3 Field strength
 - 2.2.4 Test coil and shape
 - 2.2.5 Hall elements
- 3.0 Signal-to-Noise Ratio
 - 3.1 Definition
 - 3.2 Relationship to eddy current testing
 - 3.3 Methods of improving signal-to-noise ratio
- 4.0 Selection of Test Frequency
 - 4.1 Relationship of frequency to type of test
 - 4.2 Considerations affecting choice of test
 - 4.2.1 Signal-to-noise ratio
 - 4.2.2 Causes of noise
 - 4.2.3 Methods to reduce noise
 - 4.2.3.1 DC saturation
 - 4.2.3.2 Shielding
 - 4.2.3.3 Grounding
 - 4.2.4 Phase discrimination
 - 4.2.5 Response speed
 - 4.2.6 Skin effect
- 5.0 Coupling
 - 5.1 Fill factor
 - 5.2 Lift-off
- 6.0 Field Strength and its Selection
 - 6.1 Permeability changes
 - 6.2 Saturation
 - 6.3 Effect of AC field strength on eddy current testing
- 7.0 Instrument Design Considerations
 - 7.1 Amplification
 - 7.2 Phase detection
 - 7.3 Differentiation of filtering

Techniques and Applications Course

- 1.0 User Standards and Operating Procedures
 - 1.1 Explanation of standards and specifications used in eddy current testing
- 2.0 Inspection System Output
 - 2.1 Accept/reject criteria
 - 2.1.1 Sorting, go/no-go
 - 2.2 Signal classification processes
 - 2.2.1 Discontinuity
 - 2.2.2 Flaw
 - 2.3 Detection of signals of interest
 - 2.3.1 Near surface
 - 2.3.2 Far surface
 - 2.4 Flaw sizing techniques
 - 2.4.1 Phase to depth
 - 2.4.2 Volts to depth
 - 2.5 Calculation of flaw frequency
 - 2.6 Sorting for properties related to conductivity

- 2.7 Thickness evaluation
- 2.8 Measurement of ferromagnetic properties
 - 2.8.1 Comparative circuits

Remote Field Testing Level I Topical Outline

Theory Course

- 1.0 Introduction to Remote Field Testing
 - 1.1 Historical and developmental process
 - 1.1.1 Founding fathers: McLean, Schmidt, Atherton and Lord
 - 1.1.2 The computer age and its effect on the advancement of remote field testing (RFT)
 - 1.2 Basic physics and controlling principles
 - 1.2.1 Varying magnetic fields
 - 1.2.2 Electromagnetic induction
 - 1.2.3 Primary and secondary field relationships
- 2.0 Electromagnetic Theory
 - 2.1 Generation of eddy currents in conductors
 - 2.2 Eddy current propagation and decay, standard depth of penetration
 - 2.3 Near field, transition and remote field zones
 - 2.4 Properties of remote field eddy currents
 - 2.4.1 Through-transmission nature
 - 2.4.2 Magnetic flux is predominant energy
 - 2.4.3 The ferrous tube as a wave guide
 - 2.4.4 Strength of field in three zones
 - 2.4.5 External field is source of energy in remote field
 - 2.4.6 Factors affecting phase lag and amplitude
 - 2.4.7 Geometric factors: fill factor, external support plates, tube sheets
 - 2.4.8 Speed of test, relationship to thickness, frequency, conductivity and permeability
 - 2.4.9 Effect of deposits, magnetite, copper, calcium
 - 2.4.10 Remote field testing (RFT) in nonferrous tubes

Basic Technique Course

- 1.0 Types of Remote Field Sensing Elements
 - 1.1 Probes
 - 1.1.1 Types of arrangements
 - 1.1.1.1 Absolute bobbin coils
 - 1.1.1.2 Differential bobbin coils
 - 1.1.1.3 Arrays
 - 1.1.2 Modes of operation
 - 1.1.2.1 RFT voltage plane and reference curve
 - 1.1.2.2 X-Y voltage plane
 - 1.1.2.3 Chart recordings
 - 1.1.3 Theory of operation
 - 1.1.4 Applications
 - 1.1.4.1 Heat exchanger and boiler tubes
 - 1.1.4.2 Pipes and pipelines
 - 1.1.4.3 External and through-transmission probes
 - 1.1.5 Advantages
 - 1.1.5.1 Equal sensitivity to internal and external flaws
 - 1.1.5.2 Easy to understand: increasing depth of flaw signals rotate CCW
 - 1.1.6 Limitations



Documents

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- 1.1.6.1 Speed
 - 1.1.6.2 Difficult to differentiate internal versus external flaws
 - 1.1.6.3 Small signals from small volume flaws
 - 1.1.6.4 Finned tubes
- 1.2 Factors affecting choice of probe type
 - 1.2.1 Differential for small volume flaws (e.g. pits)
 - 1.2.2 Absolute for large area defects (e.g. steam erosion, fretting)
 - 1.2.3 Test (probe travel) speed
 - 1.2.4 Single versus dual exciters and areas of reduced sensitivity
 - 1.2.5 Bobbin coils and solid state sensors
 - 1.2.6 Finned tubes
- 2.0 Selection of Inspection Parameters
 - 2.1 Frequency
 - 2.2 Coil drive: current/voltage
 - 2.3 Pre-amp gain
 - 2.4 Display gain
 - 2.5 Standardization
- 3.0 Readout Mechanisms
 - 3.1 Display types:
 - 3.1.1 RFT voltage plane displays
 - 3.1.2 Voltage vector displays
 - 3.2 RFT reference curve
 - 3.3 Chart recordings
 - 3.4 Odometers
 - 3.5 Storing and recalling data on computers

Principles Course

- 1.0 Review of Electromagnetic Theory
 - 1.1 RFT theory
 - 1.2 Types of RFT 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 (fill factor)
 - 2.2.3 Field strength (drive volts, frequency)
 - 2.2.4 Coil shapes
- 3.0 Signal-to-Noise Ratio
 - 3.1 Definition
 - 3.2 Relationship to RFT testing
 - 3.3 Methods of improving signal-to-noise ratio:
 - 3.3.1 Speed
 - 3.3.2 Fill factor
 - 3.3.3 Frequency
 - 3.3.4 Filters
 - 3.3.5 Drive
 - 3.3.6 Shielding
 - 3.3.7 Grounding [(6) and (7) also apply to other methods]

- 4.0 Selection of Test Frequency
 - 4.1 Relationship of frequency to depth of penetration
 - 4.2 Relationship of frequency to resolution
 - 4.3 Dual frequency operation
 - 4.4 Beat frequencies
 - 4.5 Optimum frequency
- 5.0 Coupling
 - 5.1 Fill factor
 - 5.2 Importance of centralizing the probe
- 6.0 Field Strength
 - 6.1 Probe drive and penetration
 - 6.2 Effect of increasing thickness, conductivity or permeability
 - 6.3 Position of receive coils versus field strength
- 7.0 Instrument Design Considerations
 - 7.1 Amplification
 - 7.2 Phase and amplitude detection (lock-in amplifier)
 - 7.3 Differentiation and filtering

Remote Field Testing Level II Topical Outline

Techniques and Applications Course

- 1.0 Equipment
 - 1.1 Probes
 - 1.1.1 Absolute bobbin coils
 - 1.1.2 Differential bobbin coils
 - 1.1.3 Arrays
 - 1.1.4 Dual exciter or dual detector probes
 - 1.1.5 Solid state sensors
 - 1.1.6 External probes
 - 1.1.7 Effect of fill factor
 - 1.1.8 Centralizing the probe
 - 1.1.9 Quality of the “ride”
 - 1.1.10 Cable length considerations
 - 1.1.11 Pre-amps internal and external
 - 1.2 Instruments
 - 1.2.1 Measuring phase and amplitude
 - 1.2.2 Displays: remote field testing (RFT), voltage plane, impedance plane differences
 - 1.2.3 Chart recordings
 - 1.2.4 Storing, retrieving, archiving data
 - 1.2.5 Standardization frequency
 - 1.3 Reference standards
 - 1.3.1 Material
 - 1.3.2 Thickness
 - 1.3.3 Size
 - 1.3.4 Heat treatment
 - 1.3.5 Simulated defects
 - 1.3.6 ASTM E 2096
 - 1.3.7 How often to standardize
- 2.0 Techniques
 - 2.1 Factors affecting signals
 - 2.1.1 Probe speed/smoothness of travel
 - 2.1.2 Depth, width and length of flaw versus probe footprint



Documents

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- 2.1.3 Probe drive, pre-amp gain, view gain, filters
- 2.1.4 Position of flaw versus other objects (e.g. support plates)
- 2.1.5 Fill factor
- 2.1.6 Signal-to-noise ratio
- 2.1.7 Thickness, conductivity and permeability of the tube
- 2.1.8 Correct display of the signal
- 2.2 Selection of test frequencies
 - 2.2.1 Single or dual or multi-frequency
 - 2.2.2 Sharing the time slice
 - 2.2.3 Number of readings per cycle
 - 2.2.4 Beat frequencies, harmonics and base frequencies
 - 2.2.5 Optimum frequency
 - 2.2.6 Saturating the input amplifier (large volume defects)
 - 2.2.7 Small volume defects: optimizing the settings to detect
- 3.0 Applications
 - 3.1 Tubulars using internal probes
 - 3.1.1 Heat exchanger tubes
 - 3.1.2 Boiler tubes
 - 3.1.3 Pipes
 - 3.1.4 Pipelines
 - 3.1.5 Furnace tubes
 - 3.2 Tubulars using external probes
 - 3.2.1 Boiler tubes
 - 3.2.2 Process pipes
 - 3.2.3 Pipelines
 - 3.2.4 Structural pipes
 - 3.3 Other applications
 - 3.3.1 Flat plate
 - 3.3.2 Finned tubes
 - 3.3.3 Hydrogen furnace tubes
 - 3.3.4 Nonferrous tubes and pipes
 - 3.3.5 Cast-iron water mains
 - 3.3.6 Oil well casings
- 4.0 Inspection System Output
 - 4.1 Accept/reject criteria
 - 4.1.1 Customer specified or code specified
 - 4.2 Signal classification processes
 - 4.2.1 Discontinuity
 - 4.2.2 Flaw
 - 4.3 Detection of signals of interest
 - 4.3.1 Near/under support plates and tubesheets
 - 4.3.2 Flaws in the free span
 - 4.3.3 Internal and external flaws
 - 4.3.4 Recognition of signals from non-flaws
 - 4.4 Signal recognition, data analysis and flaw sizing techniques
 - 4.4.1 Understanding the RFT reference curve and using it for flaw sizing
 - 4.4.2 Using phase angle to calculate flaw depth on the X-Y display
 - 4.4.3 Coil footprint considerations

Electromagnetic Testing Level III Topical Outline

Eddy Current Testing

- 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 currents
 - 1.1.3.1 Travel mode
 - 1.1.3.2 Depth of penetration
 - 1.1.3.3 Effects of test part characteristics – conductivity and permeability
 - 1.1.3.4 Current flow
 - 1.1.3.5 Frequency and phase
 - 1.1.3.6 Effects of permeability variations – noise
 - 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 and hall elements
 - 2.2.1 Advantages/limitations/differences
 - 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, X-Y and other 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
 - 2.5.4 Thresholds, box gates, etc.
- 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 Standardization
 - 3.6.1 Techniques
 - 3.6.2 Reference standards
- 3.7 Techniques – general
 - 3.7.1 Thickness
 - 3.7.2 Sorting
 - 3.7.3 Conductivity
 - 3.7.4 Surface or subsurface flaw detection
 - 3.7.5 Tubing
- 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

Remote Field Testing

- 1.0 Remote Field Testing (RFT) Principles and Theories
 - 1.1 Three zones in RFT
 - 1.1.1 Near field (direct field)
 - 1.1.2 Transition zone
 - 1.1.3 Remote field zone
 - 1.2 Through-transmission nature of RFT
 - 1.3 Standard depth of penetration factors
 - 1.3.1 Thickness
 - 1.3.2 Permeability
 - 1.3.3 Conductivity
 - 1.3.4 Frequency
 - 1.3.5 Geometry
 - 1.4 Signal analysis
 - 1.5 Display options
 - 1.5.1 Voltage plane (polar coordinates)
 - 1.5.2 X-Y display (rectilinear coordinates)
 - 1.5.3 Chart recordings: phase, log-amplitude, magnitude, X-Y
 - 1.6 Advanced applications
 - 1.6.1 Array probes
 - 1.6.2 Large pipes
 - 1.6.3 Flat plates
 - 1.6.4 Nonferrous applications
 - 1.6.5 Effects of tilt and shields
 - 1.6.6 Effects of cores and magnets
- 2.0 Codes and Practices
 - 2.1 Writing procedures
 - 2.2 ASTM E 2096
 - 2.3 *SNT-TC-1A*
 - 2.3.1 Responsibility of Level III
 - 2.4 Supervision and training
 - 2.5 Administering exams
 - 2.6 Ethics
 - 2.7 Reports: essential elements, legal responsibility

Alternating Current Field Measurement Testing

- 1.0 Principles and Theory
 - 1.1 Generation of eddy currents
 - 1.2 Effect of fields created by eddy currents
 - 1.3 Properties of eddy currents
 - 1.3.1 Depth of penetration
 - 1.3.2 Effects of test part characteristics
 - 1.3.3 Current flow
 - 1.3.4 Frequency
 - 1.3.5 Effects of permeability variations
 - 1.3.6 Effects of discontinuity orientation
- 2.0 Equipment and Materials
 - 2.1 Alternating current measurement probes general
 - 2.1.1 Advantages and limitations
 - 2.2 Factors affecting choice of probes
 - 2.2.1 Type of part to be inspected
 - 2.2.2 Type of discontinuity to be inspected
 - 2.2.3 Speed of testing required
 - 2.2.4 Amount of testing required
 - 2.2.5 Probable location of discontinuity
 - 2.2.6 Applications other than discontinuity detection
 - 2.3 Techniques/equipment sensitivity
 - 2.3.1 Selection of test frequency
 - 2.3.2 Selection of correct probe scalings in relation to the test
 - 2.3.3 Selection of correct communication rates
- 3.0 Interpretation and Evaluation of Signals
 - 3.1 Flaw detection
- 4.0 Procedures

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Ground Penetrating Radar Level I Topical Outline

Theory Course

1.0 Introduction to Ground Penetrating Radar (GPR)

1.1 Radar

- 1.1.1 Reflection
- 1.1.2 Radar equation
- 1.1.3 Polarization
- 1.1.4 Interference

1.2 The history of GPR

2.0 Electromagnetic Theory

2.1 Electromagnetic wave propagation

2.2 Velocity

2.3 Wavelength

2.4 Interference

2.4.1 Attenuation

2.4.2 Dispersion

2.4.3 Noise

2.4.4 Clutter

2.5 Electrical properties

2.5.1 Relative dielectric permittivity

2.5.2 Electrical conductivity

2.5.3 Dielectric materials

2.5.3.1 Conductors

2.5.3.2 Insulators

2.5.3.3 Semiconductors

2.5.4 Types of materials

2.5.4.1 Soil

2.5.4.2 Concrete

2.5.4.3 Rocks

2.5.4.4 Water – salt/fresh

2.5.4.5 Ice

2.5.4.6 Others

2.6 Magnetic properties in materials

2.6.1 Ferromagnetic

2.6.2 Ferrimagnetic

2.6.3 Super paramagnetic

3.0 GPR Equipment

3.1 Antennas

3.1.1 Polarization

3.1.2 Fresnel reflection

3.1.3 Snell angle

3.1.4 Near field/far field

3.1.5 Frequencies



Documents

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- 3.2 Coupling
 - 3.2.1 Impedance matching
 - 3.2.2 Unloading
 - 3.2.3 Ringing
- 3.3 Waveguides

Basic Techniques Course

- 1.0 Surveys
 - 1.1 Defining the objectives
 - 1.2 Antenna selection and orientation
 - 1.2.1 Speed
 - 1.2.2 Frequency
 - 1.2.3 Application
 - 1.2.4 Materials
 - 1.2.5 Targets
 - 1.3 Depth of penetration
 - 1.3.1 Gain controls
 - 1.3.2 Sensitivity controls
 - 1.3.3 Calibration
 - 1.4 Range settings
 - 1.5 Filter settings
 - 1.6 Scanning parameters
 - 1.6.1 Mapping
 - 1.6.2 Grid layout
 - 1.6.3 Spacing
- 2.0 Applications
 - 2.1 Test methods
 - 2.2 Advantages
 - 2.3 Limitations
- 3.0 Data Display and Interpretation
 - 3.1 Material properties
 - 3.2 Layer reflection
 - 3.2.1 Trench effect
 - 3.3 Target reflection
 - 3.3.1 Point targets
 - 3.4 Detection accuracy
 - 3.5 Horizontal accuracy and resolution
 - 3.6 Depth accuracy and resolution
 - 3.7 Measurement techniques

Ground Penetrating Radar Level II Topical Outline

Principles and Applications Course

- 1.0 Review of Electromagnetic Theory
 - 1.1 Radar equation
 - 1.2 Stokes vector
 - 1.3 Mueller matrix
 - 1.4 Poincaré sphere
- 2.0 Types of Tests

- 3.0 Factors Affecting Tests
 - 3.1 Depth of investigation
 - 3.2 Orientation
 - 3.3 Noise
 - 3.3.1 Signal-to-noise ratios
 - 3.3.2 Causes
 - 3.3.3 Filters
 - 3.4 Interferences
 - 3.5 Noninvasive surfaces
- 4.0 Field Strength
 - 4.1 Antenna drive
 - 4.2 Effects of conductivity
 - 4.3 Permeability effects
 - 4.4 Ground truth
 - 4.5 Hyperbolic shape analysis
- 5.0 Instrument Design Considerations
 - 5.1 Waveguides
 - 5.2 Multipathing
 - 5.3 Near field and far field factors
 - 5.4 Resonance
 - 5.5 Resolution
- 6.0 Data
 - 6.1 Data acquisition
 - 6.2 Data processing
 - 6.2.1 Displays
 - 6.3 Modeling
 - 6.4 Interpretation
 - 6.4.1 Uncertainty

Ground Penetrating Radar Level III Topical Outline

Theory Course

- 1.0 Introduction
 - 1.1 History
 - 1.2 Applications
- 2.0 Systems Design
 - 2.1 Range
 - 2.1.1 Antenna loss
 - 2.1.2 Transmission loss
 - 2.1.3 Coupling loss
 - 2.1.4 Mismatch
 - 2.1.5 Target scatter
 - 2.1.6 Material attenuation
 - 2.2 Velocity propagation
 - 2.3 Clutter
 - 2.4 Resolution
 - 2.4.1 Depth
 - 2.4.2 Plan
- 3.0 Modeling
 - 3.1 Time domain models
 - 3.2 Antenna radiation



- 3.3 Numerical modeling
 - 3.3.1 Schemes
 - 3.3.2 Applications
 - 3.3.3 Absorbing boundary conditions (ABC) properties
- 3.4 Target shape effects
- 4.0 Material Properties
 - 4.1 Dielectric materials
 - 4.2 Ice, water
 - 4.3 Soils, rocks
 - 4.4 Suitability
 - 4.5 Man-made materials
 - 4.6 Techniques
 - 4.7 Measurement techniques
- 5.0 Antennas
 - 5.1 Types
 - 5.1.1 Element
 - 5.1.2 Traveling wave
 - 5.1.3 Impulse radiating
 - 5.1.4 Frequency dependent
 - 5.1.5 Horn
 - 5.1.6 Dielectric antennas
 - 5.2 Arrays
 - 5.3 Polarization
- 6.0 Signal Modulation
 - 6.1 Ultra-wideband signal resolution
 - 6.1.1 Waveform characteristics
 - 6.1.2 Signals
 - 6.1.2.1 Time domain
 - 6.1.2.2 Noise
 - 6.1.2.3 Comparisons
 - 6.1.2.4 Spectra comparisons
 - 6.2 Amplitude modulation
 - 6.3 Continuous wave frequency modulation
 - 6.4 Polarization modulation
- 7.0 Signal processing
 - 7.1 A-scan processing
 - 7.1.1 Zero offset
 - 7.1.2 Noise
 - 7.1.3 Clutter
 - 7.1.4 Gain
 - 7.1.5 Filtering
 - 7.1.6 Target resonances
 - 7.2 B-scan processing
 - 7.3 C-scan processing
 - 7.4 Migration
 - 7.5 Image processing
 - 7.6 De-convolution
 - 7.7 Data acquisition
 - 7.8 Data processing
 - 7.9 Microwave
 - 7.10 Clutter
 - 7.11 Anomalies

Applications Course

- 1.0 Archeology
 - 1.1 Application
 - 1.2 Identification
- 2.0 Civil Engineering
 - 2.1 Roads and pavement
 - 2.2 Conduits
 - 2.3 Techniques
 - 2.4 Concrete
 - 2.4.1 Walls
 - 2.4.2 Reinforcement
 - 2.4.3 Dowels and anchors
 - 2.5 Buildings
 - 2.5.1 Masonry
 - 2.5.2 Floors
 - 2.5.3 Walls
 - 2.5.4 Joints
 - 2.6 Tunnels
- 3.0 Forensic Applications
 - 3.1 Principles of search
 - 3.2 Methods
 - 3.3 Graves
 - 3.4 Remains
 - 3.5 Excavation
 - 3.6 Examples
- 4.0 Geophysical Applications
 - 4.1 Radar systems
 - 4.2 Frozen materials
 - 4.2.1 Short pulse and FMCW radar
 - 4.2.2 Firm layering and isochrones
 - 4.2.3 Crevasses detection
 - 4.2.4 Hydraulic pathways
 - 4.2.5 Topography
 - 4.2.6 Lake ice
 - 4.3 Polythermal glaciers
 - 4.3.1 Radar system
 - 4.3.2 Bottom topography
 - 4.3.3 Internal structure
 - 4.3.4 Snow cover
 - 4.4 Oil spills
 - 4.5 Contaminations
 - 4.6 Soil erosion
 - 4.7 Coal and salt
 - 4.8 Rocks
- 5.0 Bore Hole Radar (Long Distance)
 - 5.1 Radar design
 - 5.2 Data
 - 5.3 Subsurface fracture characterization
 - 5.4 Radar polarimetry
 - 5.5 Specifications
 - 5.6 Data acquisition
 - 5.7 Problems
 - 5.8 Signal/image processing
 - 5.9 EM modeling



Documents

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- 6.0 Mine Detection
 - 6.1 Humanitarian and military programs
 - 6.1.1 United States
 - 6.1.2 Europe
 - 6.1.3 Others
 - 6.2 Performance assessment
 - 6.3 Mine detection
 - 6.3.1 Handheld
 - 6.3.2 Vehicle mounted
 - 6.3.3 Airborne
 - 6.3.4 Data processing
 - 6.3.5 Clutter characteristics and removal
- 7.0 Utilities
 - 7.1 Technology
 - 7.2 Pipes and cables
 - 7.3 Pipe hawk
 - 7.4 Mapping
 - 7.5 Drainage
 - 7.6 Inspection of pipe
- 8.0 Remote Sensing
 - 8.1 Airborne systems
 - 8.2 Satellite systems
 - 8.3 Planetary exploration
 - 8.3.1 Interplanetary body measurement
 - 8.3.2 Scientific objectives
 - 8.3.3 Models
 - 8.3.4 Performance
- 9.0 Equipment
 - 9.1 Survey methods
 - 9.2 Site characteristics
 - 9.3 Surface characteristics
 - 9.4 Material characteristics
 - 9.5 Target characteristics
- 10.0 Regulations, Radiological Aspects and EMC
 - 10.1 U.S. regulations
 - 10.2 European regulations
 - 10.3 Radiological aspects
 - 10.4 EMC

Training References

Ground Penetrating Radar Method, Level I, II and III

Daniels, D., ed., *Ground Penetrating Radar*, second edition. London, UK: The Institution of Engineering and Technology. 2004.

Jol, H.M. ed. *Ground Penetrating Radar Theory and Applications*. Oxford, UK: Elsevier Science. 2009.

Laser Testing Methods – Holography/Shearography Testing Level I Topical Outline

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
 - 2.2 Light as a wave
 - 2.3 Definition of coherence
 - 2.4 Speckle
 - 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 Dangers of intra-beam viewing
 - 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

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 Dangers of intra-beam viewing
 - 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 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 SNT setup
 - 6.3 Video caliper calibration
- 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 Videotape

- 9.0 Holography/Shearography Systems
 - 9.1 Basic holography/shearography system
 - 9.2 Production systems
 - 9.3 Field inspection systems
 - 9.4 Advanced systems

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
 - 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 Biaxial strain implications
 - 6.3 Applications
 - 6.4 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
 - 7.1.4 White noise
 - 7.2 Phase reversing
 - 7.3 Applications
 - 7.4 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
 - 8.1.4 White noise
 - 8.2 Phase reversing
 - 8.3 Applications
 - 8.4 Interpretation of results
 - 8.5 Safe use of acoustic exciters
- 9.0 Complex Structures
 - 9.1 Types of constructions
 - 9.2 Interpretation of results

Holography/Shearography Testing Level II Topical Outline

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 Transparent and translucent materials
 - 4.6 Mechanical stress/strain
 - 4.7 Thermal expansion of materials
 - 4.8 Vacuum stress and out-of-plane strain
 - 4.9 Pressure, axial and hoop strain
 - 4.10 Vibration and resonance
 - 4.11 Stress relaxation

Intermediate Operating Course

- 1.0 Holography and Shearography Systems
 - 1.1 Automated inspection stations
 - 1.2 Tripod-based 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)
 - 4.2 Resolution versus FOV
 - 4.3 Focus and iris settings
 - 4.4 Sensitivity versus shear angle
 - 4.5 In-plane, out-of-plane considerations
 - 4.6 Effects of shear orientation
 - 4.7 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
 - 7.2 Method format
- 8.0 Documentation
 - 8.1 Digital image file management
 - 8.2 Reporting
 - 8.3 Video prints
 - 8.4 Videotapes
 - 8.5 Archiving data

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
 - 1.6 Plasma spray and ceramics
 - 1.7 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
 - 3.2.3 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
 - 5.2.2 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
 - 8.1.4 Sweep rate
 - 8.1.5 White noise
 - 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

Laser Methods Holography/Shearography Testing Level III Topical Outline

- 1.0 Principles/Theory
 - 1.1 Light
 - 1.1.1 Light and basic wave theory
 - 1.1.2 Coherence and interference
 - 1.1.3 Electronic speckle
 - 1.1.4 Speckle interferometry
 - 1.2 Lasers
 - 1.2.1 Laser principles
 - 1.2.2 Properties of laser light
 - 1.2.3 Laser light as a measurement tool
 - 1.2.4 Ion lasers
 - 1.2.5 Diode lasers
 - 1.3 Optics
 - 1.3.1 Holographic optics
 - 1.3.2 Shearography optics
 - 1.3.3 Polarization
 - 1.3.4 Filters
 - 1.4 Material properties
 - 1.4.1 Stress/strain, the modulus of elasticity
 - 1.4.2 Plate deformation equation
 - 1.4.3 Deformation versus strain
 - 1.4.4 Specular versus diffuse reflections
 - 1.4.5 Transparent and translucent materials
 - 1.4.6 Thermal expansion of materials
 - 1.4.7 Vacuum stress and out-of-plane strain
 - 1.4.8 Pressure, axial and hoop strain
 - 1.4.9 Vibration and resonance
 - 1.4.10 Stress relaxation
- 2.0 Equipment/Materials
 - 2.1 Holographic systems
 - 2.1.1 Fundamentals of holography
 - 2.1.2 Holographic instruments
 - 2.1.3 Interpreting results
 - 2.2 Shearographic systems
 - 2.2.1 Image subtraction correlation systems
 - 2.2.2 Phase stepping systems
 - 2.2.3 Production systems
 - 2.2.4 Automated systems
 - 2.2.5 Field inspection systems
 - 2.3 Basic setup
 - 2.3.1 Illumination
 - 2.3.1.1 Illumination versus field of view
 - 2.3.1.2 Laser speckle considerations
 - 2.3.1.3 In-plane, out-of-plane considerations
 - 2.3.2 Fixturing
 - 2.3.2.1 Simple forms
 - 2.3.2.2 Automated system requirements