# Acoustic Emission Testing Course

## Level II - Outline

I. Principles of AE Testing
   a. Characteristics of AE Testing
      i. Introductory concepts of source, propagation, measurement, display, evaluation
      ii. Relationships between AE and other NDT methods
      iii. Significance of applied load in AE testing
      iv. Basic Math review

   b. Materials and Deformation
      i. Constitution of crystalline and noncrystalline materials
      ii. Stress and strain
      iii. Elastic and plastic deformation; Crack growth

   c. Sources of AE
      i. Burst emission, Continuous emission
      ii. Emission signals/levels, units of amplitude measurement
      iii. Sources in crystalline materials
         1. Dislocations – plastic deformation
         2. Phase transformations
         3. Deformation twinning
         4. Nonmetallic inclusions
         5. Subcritical crack growth
            a. Subcritical crack growth under increasing load
            b. Ductile tearing under increasing load
            c. Fatigue crack initiation and growth
            d. Hydrogen embrittlement and cracking
            e. Stress corrosion and cracking
      iv. Sources in nonmetals
         1. Microcracking
         2. Gross cracking
         3. Crazing
         4. Other sources in nonmetals
      v. Sources in composites
         1. Fiber breakage
         2. Matrix cracking
         3. Fiber-matrix debonding
         4. Delamination
         5. Fiber pull-out, relaxation
         6. Friction
      vi. Other sources
         1. Pressure leaks
         2. Oxide and scale cracking
         3. Slag cracking
         4. Frictional sources
         5. Liquefaction and solidification

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6. Loose parts, intermittent contact
7. Fluids, and nonsolids
8. Crack closure

d. Wave Propagation
   i. Near-field impulse response
   ii. Modes of propagation
   iii. Mode conversion, reflection and refraction
   iv. Wave velocity in material
   v. Anisotropic propagation in composites
   vi. Specimen geometry effects

e. Attenuation
   i. Geometric attenuation
   ii. Dispersion
   iii. Scattering, diffraction
   iv. Attenuation due to energy loss mechanisms
   v. Attenuation vs. frequency

f. Kaiser and Felicity Effects, and Felicity Ratio
   i. In metals
   ii. In composites
   iii. In other materials

g. Terminology (ASTM E1316)

II. Sensing the AE Wave
a. Transducing processes (piezoelectricity, etc.)
b. Sensors
   i. Construction
   ii. Conversion efficiencies
   iii. Calibration (Sensitivity curve)
c. Sensor attachment
   i. Coupling materials
   ii. Attachment devices
   iii. Waveguides
d. Sensor utilization
   i. Flat response sensors
   ii. Resonant response sensors
   iii. Integral-electronics sensors
   iv. Special sensors (directional, mode responsive)
   v. Sensor selection

III. Instrumentation and Signal Processing
a. Cables
   i. Coaxial cable
   ii. Twisted pair cable
   iii. Noise problems in cables
   iv. Impedance matching
   v. Connectors
b. Signal conditioning

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i. Preamplifiers
ii. Amplifiers
iii. Filters
iv. Units of gain measurement

c. Signal detection
i. Threshold comparator
ii. Units of threshold measurement
iii. Sensitivity determined by gain and/or threshold

d. Signal processing
i. Waveform characteristics
1. Amplitude analysis
2. Pulse duration analysis
3. Rise time analysis
4. Event and event rate processing
5. MARSE
ii. Discrimination techniques
iii. Distribution techniques

e. Source location techniques
i. Single channel location
ii. Linear location
iii. Planar location
iv. Other location techniques

f. AE test systems
i. Single channel systems
ii. Multi-channel systems
iii. Dedicated industrial systems

g. Accessory techniques
i. Audi indicators
ii. X-Y and strip chart recording
iii. Oscilloscopes
iv. Magnetic recorders
v. Others

h. Advanced signal processing techniques
i. Signal definition
ii. Signal capture
iii. Frequency analysis
iv. Pattern recognition

IV. AE Test Techniques

a. Factors affecting testing equipment selection
i. Material being monitored
ii. Location and nature of emission
iii. Type of information desired
iv. Size and shape of test part

b. Equipment calibration and setup for test
i. Calibration signal generation techniques
ii. Calibration procedures
iii. Sensor placement
iv. Adjustment of equipment controls
v. Discrimination technique adjustments

c. Loading procedures

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i. Type of loading
ii. Maximum test load
iii. Load holds
iv. Repeated and programmed loadings
v. Rate of loading

d. Special test procedures
i. High temperature/low temperature tests
ii. Interrupted tests (including cyclic fatigue)
iii. Long term tests
iv. Tests in high noise environments

e. Data display
i. Selection of display mode
ii. Use and reading of different kinds of display

f. Noise sources and pre-test identification techniques
i. EM noise
ii. Mechanical noise

g. Precautions against noise
i. Electrical shielding
ii. Electronic techniques
iii. Prevention of movement
iv. Attenuating materials and applications

h. Data interpretation
i. Recognizing noise in the recorded data
ii. Noise elimination by data filtering techniques
iii. Relevant and nonrelevant AE response

i. Data Evaluation
i. Methods for ranking, grading, accepting/rejecting
ii. Comparison with calibration signals
iii. Source evaluation by complementary NDT methods

j. Reports
i. Purpose
ii. Content and structure
iii.

V. Codes, Standards, Procedures and Societies
i. Guide-type standards (glossaries, calibration, etc)
ii. Standardized/codified AE test procedures
iii. User-developed test procedures
iv. Societies active in AE

VI. Applications of AE Testing

a. Laboratory Studies (Material Characterization) – At least 3 categories
i. Crack growth and fracture mechanics
ii. Environmentally assisted cracking
iii. Dislocation movement (metals)
iv. Clarifying deformation mechanisms (composites)
v. Phase transformations and phase stability
vi. Creep
vii. Residual stress
viii. Corrosion
ix. Fatigue
x. Rupture

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xi. Ductile/brittle transition
xii. Other material characterization applications

b. Structural Applications – At least 4 categories
   i. Pressure vessels (metal)
   ii. Storage tanks (metal)
   iii. Composite pressure vessels/storage tanks
   iv. Piping and pipelines
   v. Bucket trucks
   vi. Aircraft
   vii. Bridges
   viii. Mines
   ix. Dams, earthen slopes
   x. Pumps, valves, etc.
   xi. Rotating plant
   xii. In-process weld monitoring
   xiii. Leak detection and monitoring
   xiv. Other structural applications

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