

# Contents

<b>1</b>	<b>The Generation of Elastic Acoustic Emission Waves Due to the Fracture of Solids</b>	<b>1</b>
1.1	Some Fracture Mechanics Criteria Under Quasi-Static Loading of Materials	1
1.1.1	Energy Criteria	4
1.1.2	Force Criteria	7
1.1.3	Deformation Criteria	11
1.2	Micro-Cracking of Solids	13
1.3	Physical Grounds of AE Generation	14
1.4	Basic Parameters of the AE Signals	17
1.4.1	Cumulative Count [60]	18
1.4.2	AE Count Rate [60]	18
1.4.3	Amplitude Distribution of AES	19
1.4.4	Spectral and Energy Distribution of AES	19
1.4.5	Identification of AES by the Waveform Type	20
1.5	Basic Analytical Dependences Between the Fracture Parameters and the AE Signals	20
	References	23
<b>2</b>	<b>Propagation of Elastic Waves in Solids</b>	<b>29</b>
2.1	Types of Elastic Waves	29
2.1.1	Some General Ideas on Elastic Strain	29
2.1.2	A Wave Equation for a Solid	31
2.1.3	Main Ideas of the Wave Process	32
2.1.4	Spatial Elastic Waves	35
2.1.5	Rayleigh Surface Wave	38
2.1.6	Head (Creeping) Wave	40
2.1.7	Waves at an Interface of Two Media	41
2.1.8	Waves in Layers and Plates	42

2.1.9	Waves in Bars . . . . .	46
2.1.10	Other Types of Waves. . . . .	47
2.2	Some Basic Acoustic Properties of Media . . . . .	50
2.2.1	Impedance and Wave Resistance of a Medium . . . . .	50
2.2.2	Decay of Elastic Waves. . . . .	51
2.2.3	Diffraction of Elastic Waves . . . . .	56
2.2.4	Refraction of Elastic Waves . . . . .	61
2.3	AE Sources. . . . .	61
	References. . . . .	69
<b>3</b>	<b>Analysis of Acoustic Emission Caused by Internal Cracks . . . . .</b>	<b>75</b>
3.1	Nucleation and Sub-critical CRACK Growth . . . . .	76
3.1.1	Nucleation of a Mode I Penny-Shaped Crack . . . . .	76
3.1.2	Nucleation of a Mode III Penny-Shaped Crack . . . . .	83
3.2	Modelling the Sub-critical Crack Growth at Local Areas of Its Contour as a Source of Acoustic Emission Signals. . . . .	88
3.3	The Effect of Body Boundaries on AE Signals Caused by the Growth of an Internal Defect. . . . .	91
3.4	The Waveguide Effect on the Change of the Parameters of AE Signals. . . . .	95
3.5	The Assessment of Surface Displacements Caused by an Internal AE Source . . . . .	98
	References. . . . .	103
<b>4</b>	<b>Some Methodological Foundations for Selecting and Processing AE Signals . . . . .</b>	<b>107</b>
4.1	Some General Methodical Guidelines on the Use of the AE Method in the Mechanical Testing of Materials with Cracks . . . .	107
4.2	Technical Aspects of Preparation for AE Tests. . . . .	111
4.3	Selection of Informative Parameters of AE Signals . . . . .	113
4.4	Simulation of AE Sources . . . . .	114
4.5	Simulation of AE Events at the AET Output . . . . .	120
4.6	Spectrum of the AE Signals During Macro-crack Growth . . . . .	124
4.7	Directional Diagram of AE Radiation During Macro-crack Growth . . . . .	130
4.8	Estimation of AE Signals Caused by Propagation of Internal Crack-like Defects . . . . .	134
4.9	Methods of the AET Mounting at IO . . . . .	139
4.10	Selection of Useful AES During AE Tests. . . . .	141
4.10.1	Selection of a Working Frequency Band of AE Facilities . . . . .	142
4.10.2	Filtration of AES by Instrumental Facilities . . . . .	148
4.10.3	Application of the “Dead Time” Mode . . . . .	148
4.10.4	The Kaiser Effect Application . . . . .	150

4.10.5	A Method of Spatial Selection of AES . . . . .	151
4.10.6	Other Methodical Approaches . . . . .	153
	References. . . . .	154
<b>5</b>	<b>Evaluation of Mechanical Characteristics and Static Crack Growth Resistance of Materials with the Use of Aes . . . . .</b>	<b>161</b>
5.1	Identification of the AES Generated During Plastic Zone Growth . . . . .	161
5.2	A Method for Evaluating a Macro-Crack Start . . . . .	165
5.3	AE Estimation of the Stages of Sub-Critical Crack Propagation. . . . .	171
5.3.1	Types of Specimens and Modes of AE Signals Selection . . . . .	171
5.3.2	Interpretation of Investigation Results . . . . .	174
5.4	Estimation of a Macro-Crack Length Increment and SIF Increase Under Static Loading . . . . .	178
5.4.1	Some Theoretical Bases for AE Estimation of Macro-Crack Propagation Parameters . . . . .	178
5.4.2	Test Results. . . . .	180
5.5	AE Estimation of Strength Characteristics of Structural Materials. . . . .	185
5.5.1	Investigation of Concrete Hardening by AE Signals [31] . . . . .	185
5.5.2	AE Estimation of AES Amplitudes at a Fracture of Concrete in the Bridge Structure . . . . .	194
5.5.3	AE Estimation of Mechanical Characteristics of Steels . . . . .	201
5.5.4	AES Generation Under Reinforced Concrete Beam Bending . . . . .	207
	References. . . . .	211
<b>6</b>	<b>Some Aspects of Applying the Acoustic Emission Method . . . . .</b>	<b>219</b>
6.1	Specific Features of Long-Term AE Testing of Industrial Objects . . . . .	220
6.1.1	Selection of a Frequency Band and AET Placing . . . . .	220
6.1.2	Calibration of an AE Testing System . . . . .	222
6.1.3	Analysis and Presentation of AE Test Results. . . . .	222
6.1.4	Stability of AE Parameters . . . . .	223
6.1.5	Classification of AE Sources by Their Activity . . . . .	228
6.2	Using the AE Methods for Testing the Offshore Platforms. . . . .	233
6.3	Using the AE for Testing the Nuclear Reactors . . . . .	236
6.4	Application of AE Method for Estimation of Strength of Pressure Vessels and Pipelines . . . . .	240

6.5	AE Inspection of Welded Joints . . . . .	243
6.5.1	Verification of Selection of Materials, the Type of Specimens, and an Investigation Method [21]. . . . .	245
6.5.2	Results of the AE Research of the Welded Joints and Their Interpretation . . . . .	247
6.6	Selective On-Line AE Hydraulic Testing of an Oil Storage Reservoir . . . . .	255
6.6.1	Some Methodological Features of AE Testing of a Reservoir . . . . .	256
6.6.2	Criteria for Classifying AE Sources. . . . .	259
6.6.3	Results of the AE Testing and Their Interpretation . . . . .	262
6.7	AE Testing and Diagnostics of Building Structures . . . . .	264
6.8	The AE Inspection of Bridges in Ukraine. . . . .	267
6.9	Prospects for Further AE Application . . . . .	276
	References. . . . .	278

Acoustic Emission

Methodology and Application

Nazarchuk, Z.; Skalskyi, V.; Serhiyenko, O.

2017, XIV, 283 p. 144 illus., 3 illus. in color., Hardcover

ISBN: 978-3-319-49348-0