



GUIDANCE NOTES ON

STRUCTURAL MONITORING USING ACOUSTIC EMISSIONS

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Foreword

Ship and offshore structures continue to become larger and more complex, requiring operators to have a more in-depth knowledge of structural integrity. There is a need for non-intrusive, real-time monitoring technique for monitoring structural health while the vessel is in operation.

Acoustic Emission Testing (AET) is a passive nondestructive examination technology that has been successfully applied to the detection and monitoring of crack propagation, corrosion activity, cavitation erosion, and leaking in structures constructed of steel, aluminum, composite and other materials. AET has found increasingly wider applications in many industries as a feasible technique for detection and health monitoring of storage tanks, suspension bridges, nuclear plants, pressure vessels, LNG tanks, mooring chains, airplanes, etc.

ABS first accepted AET in the *Guide for Vessels Intended to Carry Compressed Natural Gases in Bulk* (2005) as a feasible tool for real-time monitoring of sub-critical structural flaws. The IACS UR Z17 *Procedural Requirements for Service Suppliers* (2016) accepts AET for leak testing in gas carriers, and requires documented procedures based upon recognized standards.

These *Guidance Notes on Structural Monitoring Using Acoustic Emissions* provide best practices for planning and conducting AET in the maritime and offshore oil and gas industries. Descriptions are given to the roles of owner, class and AET service provider, and how they shall collaborate.

These Guidance Notes focus on steps to be performed rather than on the methodology of conducting AET. It is not possible for the current Guidance Notes to cover every application, because each AET application depends on several factors including vessel type, flaws to be monitored, vessel condition, and hazardous areas.

Sections 1 to 7 describe best practices for conducting AET on a ship or other floating structures. Appendices 1 to 6 provide additional background information, including codes and standards, and example applications.

These Guidance Notes become effective on the first day of the month of publication.

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SECTION 1 Introduction

1 General

Ships and offshore oil and gas platforms continue to become larger, more complex, and optimized, requiring an in-depth knowledge of structural integrity. This knowledge includes technologies for structural health examination and monitoring. For example, the *ABS Guide for Vessels Intended to Carry Compressed Natural Gases in Bulk* allows for Acoustic Emission (AE) to be used to monitor shipboard gas cylinders for potential failure.

ABS has published the *Guide for Hull Condition Monitoring Systems* that covers hull monitoring systems used for motion monitoring, stress monitoring, and voyage data monitoring. Most current hull condition monitoring systems rely on strain gauges, accelerometers, wave radar, etc., which provide information about structural response (strain). However, these systems are generally not suitable for monitoring localized areas of the hull structure.

There are circumstances when a system monitors a local area for crack growth. This may include known problem areas which need to be monitored in case a crack reoccurs or a crack continues to grow, perhaps threatening structural integrity. In this regard, acoustic emission technology shows promise as a monitoring method in ship and offshore structures. Acoustic emission techniques have been applied successfully in other industries (bridge, dam, storage tank, aerospace, nuclear plant, etc.). For the marine/offshore industry, these techniques can also apply the following applications:

- Machinery
- Auxiliary equipment
- Pressure vessel
- Pipe system
- Mooring chain (potential application)
- Subsea structures (potential application)

Acoustic emissions are sounds associated with stress waves generated by cracks and flaws in structures. These sounds of stress are in the form of elastic waves generated by the rapid release of energy from sources within a material. These elastic waves are detected by electronic monitoring devices to reveal the activity of cracks and flaws and to point to their location. Two distinctive features of the method are:

- i) It is the active growth of the cracks and flaws that produce Acoustic Emissions.
- ii) An array of Acoustic Emission sensors can monitor a substantial area and localize flaw sources if the Acoustic Emission data is acquired and analyzed properly.

Because of these features, the method is very well suited for structural health monitoring, integrity management, and early warning of failure.

Acoustic Emission Technology has the following benefits:

- It offers real time monitoring of crack propagation, corrosion activities, and cavitation erosion under the applied stress
- It detects the growth of defects in the material rather than the presence of a nonconformity
- It covers a range up to 4.75 m (15 ft) for most marine/offshore applications
- It can locate defects (acoustic emission source) by the triangulation method
- It has an accuracy of approximately 0.15 m (0.5 ft), subject to the complexity of the structure
- It is intrinsically safe and is able to monitor critical areas in hazardous zones
- Watertight Acoustic Emission equipment has been developed to monitor underwater and subsea structures
- It provides limited or no disturbance to operations

Acoustic Emission technology can be used for monitoring during the stages of:

- Welding process
- Initial proof test
- Requalification test
- In-service/monitoring
- Leak detection

3 Scope of These Guidance Notes

The purpose of these Guidance Notes is to make available an ABS document that contains information related to the use of Acoustic Emission technology for monitoring the structural health of the hull or other structures. These Guidance Notes address:

- Acoustic Emission application in marine environment (Sections 1 through 7)
- Background of acoustic emission testing (Appendices 1 through 6)

Sections 1 through 7 briefly introduce the technology, outline the test process, and identify the roles and responsibilities of the several parties involved in staging an Acoustic Emission project. By outlining the test process, it material for checklists to the AE test team, Owner, and ABS with that he can use to perform his assigned oversight role. Appendices 1 through 6 gives more technical detail about the Acoustic Emission method for those who wish to understand it in greater depth.

Through the application of Acoustic Emission as a condition-monitoring technique, owners/managers/operators should be able to expect improved structural reliability onboard their vessels or other marine installations.

5 Information to be Submitted

The following plans and information are to be submitted to ABS for review:

- Testing Plan, including structural plan and analysis appropriate to the purpose of the monitoring, locations of acoustic emission sensors, strain gauges and other sensors/meters
- A block diagram and description illustrating the operation of the system
- Details of the sensor accuracy, range, frequency response, and any Type Approvals of the sensors
- Procedure for installing the cables, sensors
- Procedure for testing the sensors and AET software
- Description of the method and capability of the data recording system
- The Operations Manual for the Acoustic Emission system

Plans are generally to be submitted in triplicate (to the Owner, AE specialist team, and ABS). In some cases, ABS may request the submission of additional information when it is considered necessary to review particular features of Acoustic Emission system.

7 Alternatives

ABS will consider arrangements which can be shown to be effective in meeting the overall standards of these Guidance Notes.

9 Terminology and Abbreviations

The terms used in this technology are presented in this Section in an alphabetical order

Acoustic Emission: Elastic waves generated by the rapid release of energy from sources within a material.

Acoustic Emission (AE) Activation: The onset of Acoustic Emission due to the application of a stimulus such as force, pressure, heat, etc.

Acoustic Emission (AE) Activity: A measure of the emission quantity, usually in the cumulative energy count, event count, ringdown count, or the rates of change of these quantities.

Acoustic Emission (AE) Amplitude: The largest voltage peak in the Acoustic Emission signal waveform; customarily expressed in dB_{AE} (decibels referred to 1 microvolt at the sensor output, before any amplification).

Acoustic Emission (AE) Channel: A single Acoustic Emission sensor and the related equipment components for transmitting, conditioning, detecting, and measuring the signals that come from it.

Acoustic Emission (AE) Detection: Recognition of the presence of a signal (typically accomplished by the signal crossing the detection threshold).

Acoustic Emission (AE) Event: A local material change giving rise to acoustic emission.

Acoustic Emission (AE) Hit: The detection and measurement of an Acoustic Emission signal on a channel.

Acoustic Emission (AE) Intensity: A measure of the level of the emission signals detected, such as the average amplitude, average Acoustic Emission energy, or average counts.

Acoustic Emission (AE) Sensor: A device containing a transducing element that converts Acoustic Emission wave motion into an electrical voltage.

Acoustic Emission (AE) Signal: The electrical signal coming from the transducing element and passing through subsequent signal conditioning equipment (e.g., amplifiers, frequency filters, etc.).

Acoustic Emission (AE) Signal Strength: The strength of the absolute value of a detected Acoustic Emission signal.

Amplitude Distribution: A display of the number of Acoustic Emission hits at (or greater than) a particular amplitude, plotted as a function of amplitude.

Attenuation: Loss of amplitude with distance as the wave travels through the test structure.

Burst Emission: A qualitative description of the discrete signal related to an individual emission event occurring within a material. These signals have clear beginnings and endings.

Calibration: Adjustment of a device to a standard and/or comparison to a known standard.

Continuous Emission: A qualitative description of the sustained signal level produced by rapidly occurring acoustic emission events.

Counts: The number of times the Acoustic Emission signal crosses the detection threshold. Also known as “ringdown counts” or “threshold crossing counts”.

Defect: A flaw whose aggregate size, shape, orientation, location, or properties do not meet specified acceptance criteria and is thus rejectable. (ASTM E 1316-07)

Discontinuity: A lack of continuity or cohesion; an intentional or unintentional interruption in the physical structure of a material or component. (ASTM E 1316-07)

Duration: The time from an Acoustic Emission signal's first threshold crossing to its last.

Evaluation: Determination of whether a relevant indication is cause to accept or to reject a material or component. (ASTM E 1316-07)

Extraneous Noise: Non-relevant indications; signals produced by causes other than Acoustic Emission, or by Acoustic Emission sources that are not relevant to the purpose of the test.

False Indication: An NDT indication that is interpreted to be caused by a condition other than a discontinuity or imperfection. (ASTM E 1316-07)

Felicity Effect: (Breakdown of the Kaiser effect) The presence of Acoustic Emission at stress levels below the maximum previously experienced.

Flaw: An imperfection or discontinuity that may be detectable by nondestructive testing and is not necessarily rejectable. (ASTM E 1316-07)

Guard Sensors: Sensors whose primary function is the elimination of extraneous noise based on arrival time differences.

Indication: The response or evidence from a nondestructive examination. (ASTM E 1316-07).

Interpretation: The determination of whether indications are relevant, non-relevant or false. (ASTM E 1316-07).

Kaiser Effect: The absence of detectable Acoustic Emission at a fixed sensitivity level, until previously applied stress levels are exceeded.

Nondestructive Testing (NDT): The development and application of technical methods to examine materials or components in ways that do not impair future usefulness and serviceability in order to detect, locate, measure, and evaluate flaws; to assess integrity, properties, and composition; and to measure geometrical characteristics.

Non-relevant Indication: An NDT indication that is caused by a condition or type of discontinuity that is not rejectable. False indications are non-relevant. (ASTM E 1316-07).

Parametric Inputs: Environmental variables (e.g., load, pressure, temperature, etc.) that can be measured and stored as part of the Acoustic Emission hit description.

Pencil Lead Break (PLB): A technique in which a mechanical pencil (typically 0.3 mm or 0.5 mm, 2H lead) is used to simulate an Acoustic Emission source for purposes of performance check, wave propagation measurements, or velocity estimates.

Performance Check: Confirmation that a device, instrument or installed system functions to a specified standard(s).

Relevant Indication: An NDT indication that is caused by a condition or type of discontinuity that requires evaluation (ASTM E 1316-07).

Risetime: The time from an Acoustic Emission (AE) signal's first threshold crossing to its peak.

Signal Features: Measurable characteristics of the Acoustic Emission signal, such as amplitude, Acoustic Emission energy, duration, counts, rise time, etc., that can be stored as part of the Acoustic Emission hit description.

Source Location: Relating to the use of multiple Acoustic Emission sensors for determining the relative positions of the Acoustic Emission sources.

Zone Radius: The maximum distance a Pencil Lead Break (PLB) is detected by instrumentation.



SECTION 2 Application of Acoustic Emission in the Marine and Offshore Industry

1 General

Acoustic Emission testing is a nondestructive testing method that has successfully been applied in the petrochemical industry since the early 1980s with several well-proven codes and standards. In the shipping industry this NDT method has been applied successfully in oil tankers and containerships. As with any NDE method, it is important to create a uniform technique that has been tried and proven. These Guidance Notes establish a repeatable and reliable technique for the early detection of structural flaws in critical areas, which include fatigue critical structural details, non-redundant structural elements, and any important structure that is not ordinarily available for close-up visual inspection. Also, Acoustic Emission Testing can monitor a known fault while awaiting repair. This would provide the vessel owner with a planning tool to arrange the drydocking and repairs, thus reducing the risk of sea damage to the cargo and/or loss of cargo.

3 Test Modes and Overall Process

Acoustic Emission can be applied in either of two test modes:

- *Periodic Inspection.* Data is taken on specific occasions or under specific conditions (for example, a specific voyage or a specific port loading process). Typically, there would be several years between successive inspections. This can be considered as part of the vessel's NDT program.
- *Continuous Monitoring.* Equipment is installed on a permanent or semi-permanent basis and the critical area is monitored for an extended length of time. The equipment is in data gathering mode during a substantial part of the normal duty cycle. This mode can be considered as part of a structural health monitoring program.

The overall process for the Acoustic Emission test is shown in Section 2, Figures 1 and 2, for periodic inspection and continuous monitoring, respectively. The individual steps are discussed in later sections, as indicated.

5 Equipment and System

Acoustic Emission equipment comes in three physical forms:

- *Wired Acoustic Emission System.* Traditional equipment has sensors with their preamplifiers at the monitoring area, with cabling from each individual sensor to an input connector on the main instrument at a central location. Cables can be long (hundreds of feet). Installing the cabling can be a substantial and physically arduous part of the work involved in the test, especially on structures such as ships where access to the test area is not always easy.
- *Wireless Acoustic Emission System.* In recent years, wireless components have been introduced into Acoustic Emission system architecture with the goal of reducing the effort and cost involved in handling cables during Acoustic Emission field tests. Wireless technology can be used in several ways, and Acoustic Emission system architecture is evolving to take advantage of this. Wireless technology has its limitations, but clear advantages are already being realized in practical testing through ongoing technical developments and the buildup of operating experience. Some wireless systems transmit the same data that would be transmitted by a full-featured wired system. Others are lower-cost systems designed to transmit only limited types of data.

- *Portable Acoustic Emission System.* Small hand-held, battery-operated Acoustic Emission systems are also available. Typically, these have only two channels and are used by an operator working close to the sensor. They can therefore be very convenient for tasks such as noise surveys, attenuation measurements, or checks on sensor coupling and mounting.

FIGURE 1
Periodic Inspection
Using AET

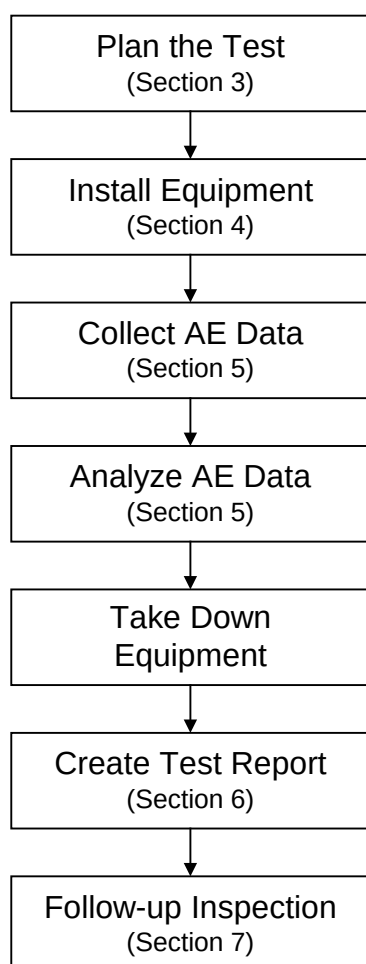
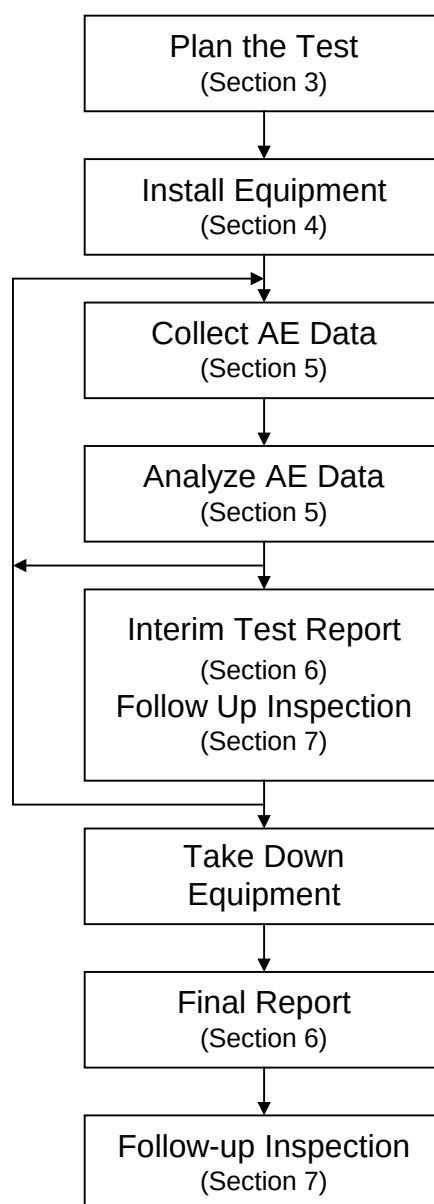


FIGURE 2
Continuous Monitoring
Using AET



7 Roles of Owner/Operator, Acoustic Emission Test Team and Classification Society (CS)

Acoustic Emission testing requires cooperation between several parties. The level of interaction is deeper than that required for typical NDT activities. The Acoustic Emission test does not disclose the size and shape of discontinuities; it goes directly to the material's response to stress and thus to structural integrity. For this reason, the Acoustic Emission test team needs to include not only Acoustic Emission specialists, but also a naval architect who is familiar with the history, design, and operation of the specific vessel and can focus the Acoustic Emission examination on the most pertinent parts of the vessel.

If the test involves strain gauges, the Acoustic Emission test team must also include personnel who are competent to install and check them.

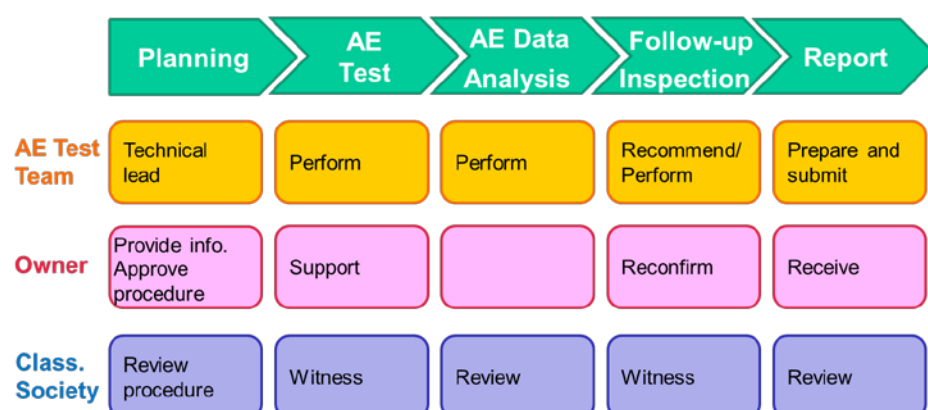
The follow-up inspection is conducted by inspectors skilled in other NDT methods, either made available by the Acoustic Emission test team, or contracted separately by the vessel owner.

The distinct roles of the main parties to the project are as follows.

- i) The role of the vessel's owner/operator is to:
 - Provide information to the Acoustic Emission test team (naval architect and Acoustic Emission specialists) about the structural conditions, history, operation, and design of the vessel
 - Approve logistical aspects of the test plan
- ii) The role of the Acoustic Emission specialists is to:
 - Prepare the plan of Acoustic Emission testing or monitoring
 - Conduct the test following these Guidance Notes and recognized Acoustic Emission standards
 - Analyze the test results, prepare the test report, and make recommendations based on the test results
- iii) The role of the naval architect is to:
 - Advise on the monitoring area
 - Approve the test plan
 - Participate in the formulation of follow-up plans and in the assessment of the significance of Acoustic Emission sources after they have been followed up with other NDT methods
- iv) The role of the classification society (CS) is to:
 - Witness tests and check the test procedure to the satisfaction of the attending ABS Surveyor
 - Review test report to the satisfaction of the attending ABS Surveyor

These responsibilities and roles are summarized in Section 2, Figure 3.

FIGURE 3
Acoustic Emission Testing: Lead Responsibilities and Roles



9 Qualification of Acoustic Emission Testing Personnel

The attending ABS Surveyor is to be satisfied that personnel responsible for conducting Acoustic Emission tests are thoroughly familiar with the equipment being used and that the technique and equipment used are suitable for the intended application. Acoustic Emission specialists are to be qualified by training and experience and certified to perform the necessary calibrations and tests and to interpret and evaluate indications in accordance with the terms of the specification. Personnel certified in accordance with the International Standard ISO 18436, Requirements for Training and Certification of Personnel, shall be classified in any one of the following three levels. Personnel who have not attained certification may be classified as trainees.

The requirements of other recognized international/national certifying programs (e.g., ASNT CP-189, SNT-TC-1A, etc.) will be specially considered.

9.1 AET Trainee

A trainee is an individual who works under the supervision of certified personnel but who does not conduct any tests independently, does not interpret test results, and does not write reports on test results. This individual may be registered as being in the process of gaining appropriate experience to establish eligibility for qualification to Level 1 or for direct access to Level 2.

9.3 AET Level 1

An individual certified to AET Level 1 may be authorized to:

- i) Apply a specified Acoustic Emission measurement procedure
- ii) Set up and verify operation of equipment for basic Acoustic Emission data collection
- iii) Verify the integrity of collected data and prevent or control poor data
- iv) Perform basic Acoustic Emission analysis
- v) Record and categorize the results in terms of written criteria
- vi) Maintain a database of results or trends
- vii) Evaluate and report test results in accordance with instructions, and highlight areas for further investigation

An individual certified to Level 1 is not to be responsible for the choice of the test method or technique to be used.

9.5 AET Level 2

An individual certified to AET Level 2 may be authorized to perform and direct Acoustic Emission testing in accordance with established or recognized procedures. This may include:

- i) Select the appropriate Acoustic Emission technique
- ii) Define the limitations of the application
- iii) Specify the appropriate hardware and software for both portable and permanently installed systems
- iv) Set up and verify equipment settings
- v) Measure and perform diagnosis of Acoustic Emission signals
- vi) Measure, interpret, and analyze Acoustic Emission data
- vii) Recommend appropriate corrective actions
- viii) Verify the calibration of Acoustic Emission measurement systems
- ix) Prepare reports on testing results
- x) Provide instruction, supervision, and technical direction to AET Level 1

9.7 AET Level 3

An individual certified to AET Level 3 may be authorized to direct any operation in the Acoustic Emission testing, including:

- i) Applying Acoustic Emission theory and techniques, including measurement and interpretation of survey results
- ii) Understanding and performing data analysis, including limitations
- iii) Determining the Acoustic Emission signature of systems and component assemblies
- iv) Usage of non-standard techniques for Acoustic Emission and fault diagnosis
- v) Recommending all generally recognized types of corrective actions
- vi) Supervising and providing guidance to AET Levels 1 and 2
- vii) Interpreting and evaluating Standards, Codes, specifications, and procedures
- viii) Establishing Acoustic Emission programs including determination of the requirement for periodic/continuous monitoring, frequency of testing, etc.
- ix) Establishing acceptance and severity criteria
- x) Preparing reports on test results

11 AET Procedures and Techniques

Procedures and techniques shall be established and approved by personnel certified to AET Level 3. Techniques shall be prepared in accordance with the requirements stated in these Guidance Notes.

Acoustic Emission Testing (AET) shall be performed by certified AET Level 1, 2, or 3 personnel. Initial interpretation and evaluation of testing results can be performed by personnel certified to AET Level 2. However, final interpretation and evaluation of testing results is to be performed by personnel certified to AET Level 3.



SECTION 3 Planning

1 Responsibilities and Task Planning

Test planning is critical to the success of the Acoustic Emission test. Planning normally starts several months before the test. The planning effort required depends largely on how familiar the vessel owner is with Acoustic Emission testing. Since the test requires installation of monitoring equipment, it requires much more planning than, for example, a simple visual inspection.

Use of the Task Planning Table (Section 3, Table 1) is recommended to aid cost-effective planning and implementation of an Acoustic Emission test or monitoring program. This table indicates the typical levels of engagement of the four involved parties (owner/operator, naval architect, Acoustic Emission specialists and classification society) in 16 detailed tasks of the project process.

Some of the tasks indicated in the table may be assigned differently in practice. For example, the table suggests that the naval architect (being an expert in stress) would be responsible for the hands-on strain gauge work, but this task might equally well be undertaken by the Acoustic Emission specialists if they were properly trained and qualified for that task.

3 Development, Approvals, and Use of the Test Procedure

For each project, a written test procedure should be developed with clearly stated revision numbers and dates, and should eventually be issued with suitable review and approval signatures. The review and approval process are decided upon within the authoring organization, having regard also to the needs of its clients/customers, regulatory bodies, etc. Some local process should be in place to verify that the procedure is prepared by suitably qualified individuals and supported by sufficient administrative/management authority.

The possibility of further revision may be allowed for in the procedure itself.

A well-thought-out and well-integrated document should lead to a successful test outcome, or failing that, at least to a solid learning process and ongoing improvement. For these benefits to be realized, it is important that the test procedure be followed. However, a test procedure is all too easily undermined by a careless inspection team or by an overriding management driven by considerations other than the technical success of this test. If these things happen, the chances of test success are much reduced.

Detailed guidance on the technical content of the test procedure is offered in Appendix 2.

5 Acceptance Standards of Planning

It is incumbent upon the Engineer to be satisfied that AET personnel (AET Level 3) are qualified and certified to create the Acoustic Emission testing plan. A typical planning, shown in Section 3, Table 1, is considered acceptable.

TABLE 1
Task Planning Table

Item	Action	Owner/ Operator	AE Test Team		CS †
			Naval Architect	AE Specialists	
ADMINISTRATIVE					
1	Selection of a suitably qualified project team	***	***	***	*
2	Detailed work plan preparation and approval	*	***	***	*
3	Communication and training with the vessel’s crew	***		***	*
PLANNING – (1) STRUCTURE					
4	Study of structural history and loads and resultant stresses	***	***		**
5	Selection of critical areas for monitoring	***	***		**
PLANNING – (2) AE SYSTEM & EQUIPMENT					
6	Selection of AE equipment			***	
7	Selection of onboard locations for the AE system and displays	***		***	
PLANNING – (3) SENSORS					
8	Visual inspection and access to the AE sensor and strain gauge sites	**	***	***	*
9	Selection of AE and strain gauge sites		***	***	
10	Design of AE sensor mounting			***	
PLANNING – (4) SOFTWARE & COMMUNICATIONS					
11	Software selection and customization if needed (including integration of strain gauge data)		*	***	
12	Communications: satellite, data download options	*		***	
13	Set-up of warning levels and definition of responses	*		***	
EXECUTION AND REPORTING					
14	Installation, system checks, commissioning	*		***	**
15	Review of system checks			***	*
16	Collection and evaluation of AE data		**	***	
17	Reporting	***	***	***	***

† CS = Classification Society

*** Fully anticipate test procedure (plan and perform)

** Partially anticipate test procedure (review and evaluate)

* Monitor test procedure (witness and approve)



SECTION 4 Installation and Checks

1 General

This Section is used by the Surveyor as a checklist for witnessing the test. Acoustic Emission specialists should also be aware of these checklists.

3 Installation of Sensors and Equipment

Consideration is to be given to:

- Safety of personnel
- Equipment protection from accidental damage
- Sensor characteristics – intrinsic safety, watertightness, weathertightness
- Sensor mounting and protection
- Cable penetrations – watertightness, weathertightness
- Power supply

5 Systems Checks

The Acoustic Emission specialists establish initial setups and install as follows:

- Acoustic Emission sensors positions/spacing compatible with attenuation measurements
- Preamplifiers of Acoustic Emission sensors with band pass filters suppressing or removing unwanted noise
- Acoustic Emission equipment sensitivity, bandwidth, timing parameters, front end filters, parametrics multipliers, waveform parameters (sampling rate/pre-trigger/duration), etc., compatible with test procedure
- Computer layout files compatible with test procedure
- Strain gauges
- Other equipment (accelerometers, other available parametrics) calibrated and working

Performance checks on Acoustic Emission channels are made during and/or after the initial setup and installation:

- Pencil Break Test (PLB) for Acoustic Emission sensor coupling/mounting (during or after installation). The example test procedure given in Subsection A6/11 has extensive details on the PLB test.
- AST (Automatic Sensor Test) and/or Punch Test (promptly after installation and then from time to time during the rest of the project)

7 Acceptance Standards of Installation and System Checks

It is incumbent upon the Surveyor to be satisfied that AET personnel (AET Levels 1, 2 and 3) are qualified and certified to perform the installation of sensors, wires, the Acoustic Emission system and system checks. The typical works of installation and system check, shown in Appendices 2 and 4, are considered acceptable.

In general, all electrical systems and components and electrical installations in watertight, tank boundary, and hazardous areas are to comply with Section 4-8-4 of the *ABS Rules for Building and Classing Steel Vessels (Steel Vessel Rules)*, Section 4-3-3 of the *ABS Rules for Building and Classing Mobile Offshore Drilling Units (MODU Rules)*, or other applicable ABS Rules or Guides.

The surveys for installation of acoustic emission testing system are to be in accordance with the applicable requirements as contained in the *ABS Rules for Survey After Construction (Part 7)*, Part 7 of the *MODU Rules*, or other applicable ABS Rules or Guides.