Ensuring Vessel Integrity with Acoustic Emission Testing

A powerful tool for detecting defects, acoustic emission testing saves time and expense because there is no need to enter a vessel to inspect it

BY KEITH BROWN

The process industry involves storage and processing of many hazardous materials. Failure of this equipment can potentially result in catastrophic consequences. With increasing regulatory requirements and continued use of aging equipment, there is more emphasis being placed on the reliability of this equipment. Acoustic emission testing is playing an increasingly important role in the monitoring of this equipment.

Definition. Acoustic Emission (AE) is a transient elastic wave that has been generated within a material by the rapid release of energy from a localized source.

Practical Usage. AE (sound waves) can be captured by equipment capable of converting mechanical energy to electrical energy and visually presenting these data in a format that can be utilized to evaluate specific sound characteristics — Fig. 1. These characteristics can be used to help determine if the source of sound is originating from an actual defect or background noise.

Nondestructive Examination Method

In some respects, AE testing may not be considered purely nondestructive because an effective test procedure is designed to force a defect to deform somewhat in order to make it detectable.

Good defect detectability depends on an outside source of energy producing a sufficient level of strain across a defect to force some physical property change or movement in its vicinity. The outside source of energy can take several forms, such as pressure changes, mechanical tension/compression changes, or thermal excursions.

The premise of an AE test is to detect defects and/or damage in metal and composite materials. This is done by inducing stresses in the test specimen and forcing a defect to deform and release energy. The energy (sound waves) that is released can be detected by AE sensors mounted on the surface of the test specimen. The deformation is usually local, at a crack tip, and occurs during loading or overstressing — Fig. 2. These sound waves travel from the source along the surface and within the specimen.

The general procedure consists of subjecting the equipment to increasing stress while monitoring with sensors that are sensitive to acoustic emission. Acoustic emission sensors are strategically placed on the test specimen at distances that will allow for AE detection prior to the sound waves attenuating. Typically, crack-type emission can be detected at distances of ten to twenty feet from their origin; this is based on the attenuation factor of the test specimen. In-service equipment is typically tested to 10% over the maximum operating load for the previous six months. Pressure may be increased on-stream with nitrogen or other gas pressure or by hydrostatic loading. The pressurization must be controlled and produce minimal background noise.

To avoid failure, defects must be detected before they reach the critical size with regard to leakage or unstable crack growth. Once defects are found, fracture mechanics can determine if the defects are significant or if they can be tolerated in service. Acoustic emission is a major tool in detecting active defects because of the significant time and expense savings of not having to enter the vessel for inspection.

Acoustic emission testing is a powerful yet complex tech-
Careful considerations are essential in determining that the application to be inspected is suitable for AE.

**Client Preparations**

The preparation and the information given for the preparation of the test are the main factors that determine the success of an AE test. It is essential that the previous operating history, which includes maximum pressures and temperatures, be provided. The equipment must be slightly overstressed to produce AE; therefore, the previous stresses must be known. Following is some of the general information needed prior to AE testing:

- Type of object and size (sphere, piping, reactor, etc.)
- Material of construction
- Operating service
- Maximum operating conditions over six (6) months (pressure, temperature, level)
- Any previous test results
- Sources of potential noise that may interfere with test results
- Testing technique (loading sequence)

**Test Setup**

Before the testing is performed, the following should be completed:

- Locate the test trailer or acquisition system
- Perform an attenuation study, if needed
- Prepare the surface for sensor attachment
- Install AE sensors at each location
- Verify sensor, cable, and system setup
- Establish radio communication between control and AE operator

**Execution**

The general procedure for in-service vessels requires that the pressurization be monitored during a stepwise increase from 90% to 110% of the maximum operating pressure — Fig. 3. Pressure hold periods will be required at 90%, 100%, 105%, and 110%. The maximum operating pressure is the maximum pressure the vessel has been operated at in the last six months. This is perhaps the most critical information for the entire testing procedure.

For new vessels, pressurization is monitored during a stepwise increase from 0 to 100% of the maximum test pressure. Maximum test pressure should be 1.5 times the design pressure. Pressure hold periods will be required at 0, 50%, 65%, 85%, and 100% on the first ramp and 50%, 65%, 85%, and 98% on the second ramp — Fig. 4.

For storage tanks, the procedure requires the level to be raised in a stepwise fashion during AE monitoring — Fig. 5. The monitoring would begin at 90% of operating level and then proceed to 100%, and to 105%. The maximum operating level is the maximum level the tank has been operated at in the last six months.

**Test Results**

A preliminary site report is generally provided prior to de-mobilization to allow for follow-up testing/inspection, if required. The AE test report typically includes the following:

- Drawings that detail all sensor locations
- Clear identification of AE sources found and the associated intensity rankings
- Discussion of the significance, and meaning, of the AE results in the reporting
- Actions needed to address inspection findings
- Recommendations for future inspection planning efforts.

**Pros and Cons of the Testing Process**

Acoustic emission testing can be a valuable nondestructive testing tool for global assessment of large tanks, pressure vessels, piping, and structures, but a solid understanding of the
method limitations are necessary to prevent misconceptions of a test specimen’s integrity.

Benefits
Following are some of the benefits of AE testing:

Minimal pretest preparation. Access to the sensor locations is all that is initially required. Insulated tanks, vessels, piping, or equipment only require 4-in.-diameter insulation plugs to be removed.

Only detects active discontinuities. Original manufacturing defects that are nonemissive will not be detected during an AE test. Most times these discontinuities are not detrimental to the service of the test specimen.

Does not interfere with operating or outage schedules. Typically, AE test preparation can take place without removing the equipment from service.

Cost savings. There are substantial cost saving benefits of AE testing in lieu of performing more intrusive nondestructive examinations. Access, insulation abatement, and surface preparation are just a few of these cost-saving advantages.

Limitations
Following are some of the limitations of AE testing:

No flaw sizing capabilities. AE testing does not provide any essential attributes that allows for flaw sizing.

Dependent on adequately applied stresses. Acoustic emission from defect sources is only achievable when they have been subjected to enough stress to initiate propagation or movement.

Operator dependent. Because of the complexity of acoustic emission testing, only well-trained and knowledgeable operators should be allowed to perform the testing and evaluation responsibilities.

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Fig. 5 — Acoustic emission monitoring of a storage tank. Monitoring begins at 90% of operating level and proceeds in a stepwise fashion to 105%.