Acoustic Emission Testing: A Composite Manufacturer's Experience

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Acoustic emission testing (AE) continues to be a combination of science and art. Here is some more experience that should advance the science - and the art - of AE for all of us. Every little step helps us to improve the practice of NDT.

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Introduction

Prior to 1993, our firm's experience with acoustic emission testing (AE) was limited; but because of our subsequent involvement with two ASME programs dealing with the design, manufacture, and testing of reinforced thermosetting plastic tanks, this has changed. Our company had many interesting and sometimes trying experiences with AE in these programs, a recounting of which may be of value to other fabricators as well as AE technicians.

Our firm manufactures corrosion resistant composite tanks for the chemical processing, pulp and paper, mining, and food industries. We are the world's first composite fabricator to be authorized by ASME to manufacture and stamp Class II vessels in accordance with Section X of the Boiler and Pressure Vessel Code. Our company also holds a certificate of authorization under ASME's RTP-1 program.

Background

In accordance with Class II provisions of Section X of the Boiler and Pressure Vessel Code, AE is employed as a mandatory acceptance test for Code vessels. Acoustic emission testing is recognized by the RTP-1 Subcommittee as an optional test; it is occasionally requested by customers. To a lesser degree, our firm uses AE to evaluate the integrity of vessels manufactured in accordance with ASTM standards.

During the past five years, our firm conducted 22 tests on 15 fiberglass reinforced tanks, ranging in capacity from 150 to 2.5 x 10[6] L (40-660 000 gal). Diversity in the size of vessels, and their configuration and design conditions presented what seemed to be an endless series of challenges. With each test came situations and problems never before experienced.

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Experiences and Observations

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By far the most significant advantage is that AE is nondestructive. This is opposed to prototype testing, in which a vessel is actually destroyed under controlled conditions. Prototype testing is most commonly used in situations where several identical vessels are to be manufactured using identical methods and materials. The expense of the prototype and its testing can then be distributed among the production units, with minimal impact on the customer's expenditure. Although this may work well with multiple vessels, it is not cost effective for vessels that are unique. This is where the advantage of AE comes into play-it records fiber breakage in vessels that actually go into service. The occurrence of fiber breakage, recorded as acoustic events, can then be analyzed to determine whether the vessel is suitable for service. Public safety is of primary concern in dealing with vessels intended for pressurized applications. From the standpoint of reliability, we can be certain that vessels that are not structurally adequate for their intended use, because of either design problems or structural weakness, will not pass undetected.

Portability is another advantage. Thanks to the microcomputer, AE technicians can take their services out of the laboratory and into the field. Tests can be conducted virtually anywhere, being limited only by weather conditions and the availability of a stable source of electrical power.

Acoustic emission can not only tell us whether we have problems, but it can also give us their general location. It should be understood that this is not always possible. The size of vessel, its configuration, the number and locations of transducers used, and the level of experience of the person analyzing the data, all can affect this capability.

There is a perception that AE is excessively expensive. Given that very few manufacturers are acquainted with the costs associated with prototype testing, this is understandable. In our firm's case, every test conducted was a learning experience. We were therefore unable to predict many of the problems that ultimately led to test failures. The necessity for repeated testing introduced unexpected and irrecoverable expense and inconvenience, which at first led to disillusionment with acoustic emission testing.

Another frequent problem was extraneous noise. To give an example, composite fabricators commonly use nonstructural, fiber filled resin paste in vessel assembly. These pastes, which are used to smooth the junctions between assembled components, are ultimately encapsulated beneath layers of structural laminate. During pressurization of the vessel, these hardened, brittle, components have a tendency to crack, registering dramatic bursts of acoustic hits. The breakdown of this resin paste does not, however, affect a vessel's structural integrity. Under shop conditions, unfortunately, it is not possible to distinguish between noise created by cracking paste and that created by fiber breakage.

In most cases, extraneous noise can be reduced if the vessels are preloaded. This practice is not prohibited by the Code, so long as the vessels are not pressurized for the 12 hours preceding the test. A more stringent evaluation criterion is used for subsequent loadings.

Preloading does not, however, preclude the problem of extraneous noise during a test. This brings up the problem of unpredictability - one which can be very costly.

In accordance with Section X, vessels are to be tested at a temperature very near that of their design temperature. On more than one occasion, attaining and maintaining elevated temperatures during testing proved to be a problem. Large capacity tanks required the use of high volume hot water boilers, which were expensive to rent and to operate. Once the larger tanks were brought up to the appropriate temperature and stabilized for the test, the boilers were shut down. Due to the large volume, thermal stability in the larger tanks was never a problem.

Exactly the opposite was true for the small tanks. These were easier to heat, but keeping them above the lower limit was a serious concern. In some cases, tests were completed with only a few hundredths of a degree to spare. Heating the water during testing was not considered and option due to the fear of induced noise.

To date, the largest structures to be tested by our firm were two field assembled wastewater tanks, 16.7 ´ 11.3 m (55 ´ 37 ft) in size. The customer in this case insisted upon acoustic emission testing. Because of the lack of baseline data or clear-cut evaluation criteria for such large diameter tanks, it was agreed that rejection of these tanks should not be based solely on a high incidence of acoustic events.

As stated previously, not all of our tests were successful. Test failure was most frequently attributable to extraneous noise from such causes as the cracking resin paste. Nonetheless, indications were found. The commonest ones were simple delaminations, usually located in the secondary bonds or around corners having extremely short radii.

Other factors (unrelated to indications) that affected test results included fastener movement, differential thermal expansion, unsecured vessel supports, unstable foundations, and inspectors tripping over pressurization hoses.

Locating the emission sources can often be a difficult and frustrating process. Emitters can be large or small, conspicuous or inconspicuous, or completely hidden.

By studying the test data, a skillful AE technician should be able to see patterns that indicate an emitter's general location. Using this information, performing a careful visual examination of the vessel's interior and exterior surfaces is the next logical step. An examination performed using a strong black light can sometimes be helpful in locating deeply hidden indications, which can then be verified with ultrasound. It should be noted that the success of visual examination is adversely affected by the presence of a pigmented exterior coating, or of any resin additive that causes laminate to become opaque.

Once located, all repairable indications should be removed, and any new laminate must be given the opportunity to cure adequately before pressurization is again attempted. After the indications and other sources of noise have been properly removed, the likelihood of passing a second test should be excellent.

Conclusion

AE is a developing technology, a field in which there is ongoing research. It is a valuable tool for analysis that will grow in acceptance as its adoption increases.

Because of problems associated with tests, negative opinions do develop. Whenever possible, AE technicians should work closely with manufacturers to eliminate those conditions that can lead to test failures. Successfully doing so will help to eliminate the expense and inconvenience of repeated testing, increase understanding, and improve relationships. The positive long term benefit of this action can be enjoyed by all.

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