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## **Quantifying Degree of Sensitization in Aluminum Alloys using Acoustic Resonance and EMAT Ultrasound**

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Sensitization of 5xxx series aluminum alloys is characterized by the gradual precipitation of the alloying element magnesium as a beta phase ( $Al_3Mg_2$ ) along the grain boundaries after prolonged exposure to the environment. While the 5xxx alloy is corrosion resistant, these beta phases are corrosive and thus their formation increases the susceptibility of the alloy to intergranular corrosion and stress corrosion cracking. The standardized approach for measuring the degree of sensitization (DoS) is the ASTM G67 test standard. This test, however, is time consuming, difficult to perform, and destructive as it involves measurement of a mass loss after exposing the alloy to a nitric acid solution. Given the limitations of this test standard, there is a need to develop a nondestructive evaluation (NDE) solution that is easy-to-use, non-intrusive, and faster than current inspection methods while suitable for use outside a laboratory. This paper describes an NDE method for quantifying the DoS value in an alloy using ultrasonic measurements. The work builds upon prior efforts described in the literature which use electromagnetic acoustic transducers (EMATs) to quantify DoS based on velocity and attenuation measurements. These approaches used conventional ultrasonic inspection techniques with short-duration excitation signals (less than 3 cycles) to allow identification of the echo time-of-flight and amplitude decay pattern, but their success was limited by EMAT transducer inefficiency in general and especially at higher frequencies. To overcome these challenges, this paper presents a modified ultrasonic measurement strategy using long-duration excitation signals (greater than 100 cycles), where multiple reverberations in the material overlap. By sweeping through test frequencies, it is possible to establish an acoustic resonance when the wavelength is an integer multiple of twice the material thickness. This approach allows for greatly improved signal to noise ratios as well as higher frequency operation since the reverberations will constructively interfere at resonance. The measurement approach was evaluated on a large number of 5083 and 5456 aluminum alloys specimens that were sensitized to varying DoS values and compared to G67 test results. Relationships between DoS values and the ultrasonic velocity and attenuation were established.