



Standard Guide for Electromagnetic Acoustic Transducers (EMATs)¹

This standard is issued under the fixed designation E 1774; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

General—The usefulness of ultrasonic techniques is well established in the literature of nondestructive examination. The generation of ultrasonic waves is achieved primarily by means of some form of electromechanical conversion, usually the piezoelectric effect. This highly efficient method of generating ultrasonic waves has a disadvantage in that a fluid is generally required for mechanical coupling of the sound into the material being examined. The use of a couplant generally requires that the material being examined be either immersed in a fluid or covered with a thin layer of fluid.

Principle—An electromagnetic acoustic transducer (EMAT) generates and receives ultrasonic waves without the need to contact the material in which the acoustic waves are traveling. The use of an EMAT requires that the material to be examined be electrically conductive or ferromagnetic, or both. The EMAT as a generator of ultrasonic waves is basically a coil of wire, excited by an alternating electric current, placed in a uniform magnetic field near the surface of an electrically conductive or ferromagnetic material. A surface current is induced in the material by transformer action. This surface current in the presence of a magnetic field experiences Lorentz forces that produce oscillating stress waves. Upon reception of an ultrasonic wave, the surface of the conductor oscillates in the presence of a magnetic field, thus inducing a voltage in the coil. The transduction process occurs within an electromagnetic skin depth. An EMAT forms the basis for a very reproducible noncontact system for generating and detecting ultrasonic waves.

1. Scope

1.1 This guide is intended primarily for tutorial purposes. It provides an overview of the general principles governing the operation and use of electromagnetic acoustic transducers (EMATs) for ultrasonic examination.

1.2 This guide describes a non-contact technique for coupling ultrasonic energy into an electrically conductive or ferromagnetic material, or both, through the use of electromagnetic fields. This guide describes the theory of operation and basic design considerations as well as the advantages and limitations of the technique.

1.3 This guide is intended to serve as a general reference to assist in determining the usefulness of EMATs for a given application as well as provide fundamental information regarding their design and operation. This guide provides guidance for the generation of longitudinal, shear, Rayleigh, and Lamb wave modes using EMATs.

1.4 This guide does not contain detailed procedures for the use of EMATs in any specific applications; nor does it promote

the use of EMATs without thorough testing prior to their use for examination purposes. Some applications in which EMATs have been applied successfully are outlined in Section 9.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

E 127 Practice for Fabricating and Checking Aluminum Alloy Ultrasonic Standard Reference Blocks²

E 428 Practice for Fabrication and Control of Steel Reference Blocks Used in Ultrasonic Examination²

E 1065 Guide for Evaluating Characteristics of Ultrasonic Search Units²

E 1316 Terminology for Nondestructive Examinations²

2.2 ASNT Document:

¹ This guide is under the jurisdiction of ASTM Committee E07 on Nondestructive Testing and is the direct responsibility of Subcommittee E07.06 on Ultrasonic Method.

Current edition approved December 10, 1996. Published February 1997. Originally published as E 1774 – 95. Last previous edition E 1774 – 95.

² *Annual Book of ASTM Standards*, Vol 03.03.

