



Designation: E3209/E3209M – 20

Standard Test Method for Pavement Thickness by Magnetic Pulse Induction¹

This standard is issued under the fixed designation E3209/E3209M; 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.

1. Scope

1.1 This test method covers the equipment, field procedures, and interpretation of the results for the pavement thickness measurements produced by a magnetic pulse induction (MPI) device. Magnetic pulse induction devices induce a weak-pulsed magnetic field that causes the induction of eddy currents in metal objects disturbing the field. In order to measure pavement thickness with an MPI device, a pre-placed metal reflector is required. When the metal reflector enters into the field, an electrical signal is produced and processed through algorithms to detect and produce quantitative values for pavement thickness.

1.2 This test method also provides the details including configuration and metallurgy required to purchase and install reflectors to produce accurate and repeatable results.

1.3 This method is intended for use with plain-jointed concrete pavements, asphalt pavements, base courses with cement binders, and unbound aggregate layers. It is not applicable for continuously reinforced, mesh-reinforced, or fiber-reinforced pavement where the metal reinforcement would interfere with the magnetic field.

1.4 MPI equipment includes a device that induces the magnetic field and collects the electrical signal. The signal information is collected and processed into pavement thicknesses through algorithms programmed into the device firmware.

1.5 MPI field procedures describe the steps and processes required to collect reliable, repeatable, and accurate results from the MPI device. Critical to the accuracy are the metallurgy and configuration of the metal reflectors pre-placed prior to installation of the asphalt or concrete pavement. Also, the absence of any metallic object near the reflector is required to avoid influencing the test result.

1.6 MPI results require little interpretation when the correct reflector calibration is selected and used during the field test.

1.7 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.8 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 ASTM Standards:²

A653/A653M Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

B209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate

C174/C174M Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores

C802 Practice for Conducting an Interlaboratory Test Program to Determine the Precision of Test Methods for Construction Materials

2.2 AASHTO Standards:³

T 148 Standard Method of Test for Measuring Length of Drilled Concrete Cores

T 359-16 Standard Method of Test for Pavement Thickness by Magnetic Pulse Induction

¹ This test method is under the jurisdiction of ASTM Committee E17 on Vehicle - Pavement Systems and is the direct responsibility of Subcommittee E17.41 on Pavement Testing and Evaluation.

Current edition approved June 1, 2020. Published June 2020. Originally approved in 2019. Last previous edition approved in 2019 as E3209 – 19. DOI: 10.1520/E3209_E3209M-20.

² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from American Association of State Highway and Transportation Officials (AASHTO), 444 N. Capitol St., NW, Suite 249, Washington, DC 20001, <http://www.transportation.org>.



3. Terminology

3.1 Definitions:

3.1.1 *reflector, n*—metal disk or plate placed prior to paving operations.

4. Summary of Test Method

4.1 This test method involves the use of magnetic pulse induction technology (the scanning device) to measure the thickness of one or several pavement layers above an installed metal reflector. During the scanning process, the scanning device generates a variant (pulsating) magnetic field which induces an eddy current and a corresponding magnetic field inside the reflector. The intensity of the measured magnetic field is directly dependent upon the distance between the scanning device and a given type of reflector. A calibration file, recording the relationship between the induced magnetic field intensity and the distance, is developed for each unique type of reflector produced by the manufacturer. Reflectors are either round or square galvanized sheet steel for use with portland cement concrete pavements, or aluminum for use with asphalt pavements.

4.2 This test method involves placing reflectors prior to the paving operation. Once the pavement can be walked on without causing surface damage, the search for the reflector may begin and test measurements can be performed by the device. Upon completion of the measurement, the results can be provided. Three measurements are taken and the average of the three results is recorded as the actual pavement thickness.

5. Significance and Use

5.1 This test method covers the indirect measurement of the pavement thickness to provide a rapid, nondestructive result. The method is used to determine the compliance of asphalt or concrete pavement construction with the thickness specifications. The nondestructive thickness results for concrete pavements have shown excellent correlation (R^2 values of 99.7 %) with direct measurement of pavement thickness using AASHTO T 148 and Test Method C174/C174M.

5.2 Measurement results from MPI devices are unaffected by concrete or asphalt material composition, including the use of slag or other metallic aggregates, material temperature, or moisture content, thus allowing installers a quality control process that provides results that can be used in controlling the paving operation. In addition, quantitative results are produced to document as-built thicknesses.

5.3 Infrastructure owners use the same device to perform quality assurance activities and to accept installed facilities. Its accuracy and repeatability allow the reduction or elimination of coring requirements related to pavement thickness determination.

6. Interferences

6.1 MPI testing relies upon plain concrete or asphalt pavement where the pre-placed galvanized steel or aluminum is the only metal in and under the pavement in the evaluation area.

6.2 The test path length of between 1 m [3.34 ft] and 1.5 m [5 ft] long is critical to allow the reflector signal strength to

start with an increasing strength curve, reaching a maximum and then descending again ending with zero.

6.3 This test method can produce misleading results when metal is nearby. It is recommended that reflectors are placed 1 m [3 ft] away from any other metal present in the pavement. When this is not possible, the test path orientation should be parallel to the metallic object in order to minimize the influence of the metal. In many cases, an accurate measurement can be obtained with an offset from the test path. The minimum offset recommended is 0.33 m [1 ft].

6.4 The sensor head has to travel over the embedded reflector in order to obtain accurate results. The maximum permissible offset from the center of the reflector to the center line of the test is shown in Table 1.

TABLE 1 Maximum Recommended Side Shift

Reflector (diameter in cm)	Maximum Side Shift from Center of Measured Reflector
7 cm aluminum round	80 mm [3.25 in.]
12 cm aluminum or steel round	80 mm [3.25 in.]
30 cm aluminum or steel round	100 mm [4 in.]
36.5 cm steel square	100 mm [4 in.]

6.5 Steel-toed shoes can also affect the results. The operator's shoes should maintain a minimum of 300 mm [12 in.] away from the gauge head during the measurement process.

6.6 Slag or metallic aggregate does not affect the results if its mixture is homogeneous in the concrete mix or base material.

7. Apparatus

7.1 An electromagnetic pulse induction device that generates a variant magnetic field that creates an eddy current in a reflector capable of measuring pavement thickness.

7.2 A metal reflector that can be detected by sensors of the pulse induction device. The type of metal and the size of the reflector depend on the type and thickness of pavement that is being measured. For deeper sections, larger reflectors are needed since they create a larger magnetic field.

8. Reagents and Materials

8.1 The metal reflectors should conform to the manufacturer's specifications and the requirements listed below. Steel reflectors may have a 5 mm [0.187 in.] diameter hole in the center for a nail to secure the reflector to the base material. Aluminum reflectors shall not have any holes.

8.2 A copy of the mill Certified Material Test Report (CMTR) is requested for the lot used in the manufacturing of the plates. Manufacturing tolerances are based on ASTM standards for metal fabrication. No substitution of material specified in 8.6 and 8.7 is allowed.

8.3 Reflector quality should be checked either by the purchaser or supplier by using the MPI device. A minimum test sample of 1 % or ten reflectors of the lot supplied, whichever is greater, shall be tested and documented using the procedure described in this test method.

