



Designation: D4748 – 10 (Reapproved 2020)

Standard Test Method for Determining the Thickness of Bound Pavement Layers Using Short-Pulse Radar¹

This standard is issued under the fixed designation D4748; 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 nondestructive determination of the thickness of bound pavement layers using ground penetrating radar (GPR).

1.2 This test method may not be suitable for application to pavements which exhibit increased conductivity due to the increased attenuation of the electromagnetic signal. Examples of scenarios which may cause this are: extremely moist or wet (saturated) pavements if free electrolytes are present and slag aggregate with high iron content.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *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.* Specific hazard statements are given in Section 11.

1.5 *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

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D6087 Test Method for Evaluating Asphalt-Covered Concrete Bridge Decks Using Ground Penetrating Radar

D6429 Guide for Selecting Surface Geophysical Methods
D6432 Guide for Using the Surface Ground Penetrating Radar Method for Subsurface Investigation
E1778 Terminology Relating to Pavement Distress

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions shall be in accordance with the terms and symbols given in Terminologies **D653** and **E1778**.

3.1.2 Additional definitions can be found in subsection 3.1.3 of Guide **D6432**, and in Ref (1).³

3.1.3 *Additional Definitions:*

3.1.3.1 *bound pavement layer*—upper layers of a pavement structure consisting of aggregate materials mixed with cementitious binder such as bitumen or portland cement paste. Examples of bound pavement layers include bituminous concrete, portland cement concrete, and stabilized bases. Bound pavement layers do not include granular base and subbase materials.

3.1.3.2 *unbound pavement layer*—lower layers of a pavement structure consisting of untreated aggregate materials such as sand, gravel, crushed stone, slag, and other stabilized materials. Unbound pavement layers include base, subbase, and compacted subgrade.

4. Apparatus

4.1 The apparatus may consist of a vehicle or a cart that is equipped with the following:

4.1.1 One or more GPR antennas mounted on the vehicle, cart, or on a trailer.

4.1.1.1 The antenna for this application typically has a center frequency that ranges from 1.0 to 2.6 GHz. A typical 1.0 GHz antenna usually has a resolution sufficient to determine a minimum layer thickness of 40 mm (1.5 in.) to an accuracy of ± 5.0 mm (± 0.2 in.). Antennas emitting short pulses containing a center frequency of 2.0 GHz and higher provide resolution sufficient for determination of a minimum layer thickness less than 25 mm (1.0 in.) to an accuracy of ± 2.5 mm (± 0.1 in.).

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.

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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 The boldface numbers in parentheses refer to a list of references at the end of this standard.

4.1.1.2 Two basic types of antenna systems are in use:

(1) Air-launched antennas that are specifically designed to radiate into the air and are to be used at some distance above the pavement surface, typically 20 to 50 cm (8 to 20 in.).

(2) Ground-coupled antennas that are specifically designed to operate in contact with the pavement surface.

4.1.2 Control unit consisting of a transmitter, receiver, and timing control electronics. It transmits and receives low-power broad band radio frequency (RF) signals through the antenna. The RF signals are then converted into a signal suitable for display and resulting interpretation.

4.1.3 Distance measuring instrument (DMI) with an accuracy of ± 190 mm/km (± 1 ft/mile) and a resolution of 305 mm (12 in.) or better.

4.1.4 An optional global positioning system (GPS) with an instantaneous positioning accuracy of 1 m (3 ft) or better.

4.1.5 Personal computer suitable for data acquisition, display, and storage.

4.2 The schematic drawing in Fig. 1 illustrates a typical equipment configuration.

5. Summary of Test Method

5.1 Since this test method is based upon measurements performed by a GPR system, a brief description of the operating principles of a system is included herein.

5.2 The GPR system transmits and receives electromagnetic signals by means of an antenna. As the transmitted electromagnetic wave propagates through the pavement layers, the wave is refracted and reflected at layer interfaces and received by the antenna. The received signal is recorded by the GPR system in terms of amplitude and two-way travel time. Figs. 2 and 3 show the schematics of the two antennas types (air-launched and ground-coupled) and the typical data collected from them. Fig. 4 shows an example of the air-launched GPR data stacked in series with respect to the travel distance along the survey line.

5.3 Layer thickness can be determined using the following equation if the velocity and the two-way travel time for the radar wave to travel through a given layer are known.

$$T = v \times \frac{\Delta t}{2} \quad (1)$$

where:

T = layer thickness,

v = velocity of the radar wave through a given material, and

Δt = two-way travel time through layer.

The GPR system measures two-way travel time, so it is easily obtainable from analysis of the data. For monostatic GPR systems, the velocity of the radar wave can be estimated from the following relationship:

$$v = \frac{c}{\sqrt{\epsilon_r}} \quad (2)$$

where:

c = speed of light in air, 300 mm/nsec (11.8 in./nsec), and

ϵ_r = relative dielectric constant of layer.

Substituting Eq 2 in Eq 1 results in the following equation for layer thickness. Note that this equation is necessarily different for bistatic antennas in order to accommodate for the separation distance between the transmit and receive antennas.

$$T = \frac{\Delta t \times c}{2\sqrt{\epsilon_r}} \quad (3)$$

NOTE 1—Definitions of the terms monostatic and bistatic are provided in subsections 3.1.3.17 and 3.1.3.4, respectively, of Guide D6432. For convenience, these definitions are excerpted from Guide D6432 and repeated below.

Monostatic—(1) a survey method that utilizes a single antenna acting as both the transmitter and receiver of EM waves. (2) Two antennas, one transmitting and one receiving, that are separated by a small distance relative to the depth of interest are sometimes referred to as operating in “monostatic mode.”

Bistatic—the survey method that utilizes two antennas. One antenna radiates the EM waves and the other antenna receives the reflected waves.

5.4 The relative dielectric constant or the radar wave velocity of a layer can be obtained in one of three ways: (1) metal plate calibration; (2) ground truth cores at locations where GPR data were collected; or (3) common midpoint (CMP) method.

5.4.1 *Metal Plate Calibration*—The metal plate calibration procedure involves obtaining GPR data with the antenna

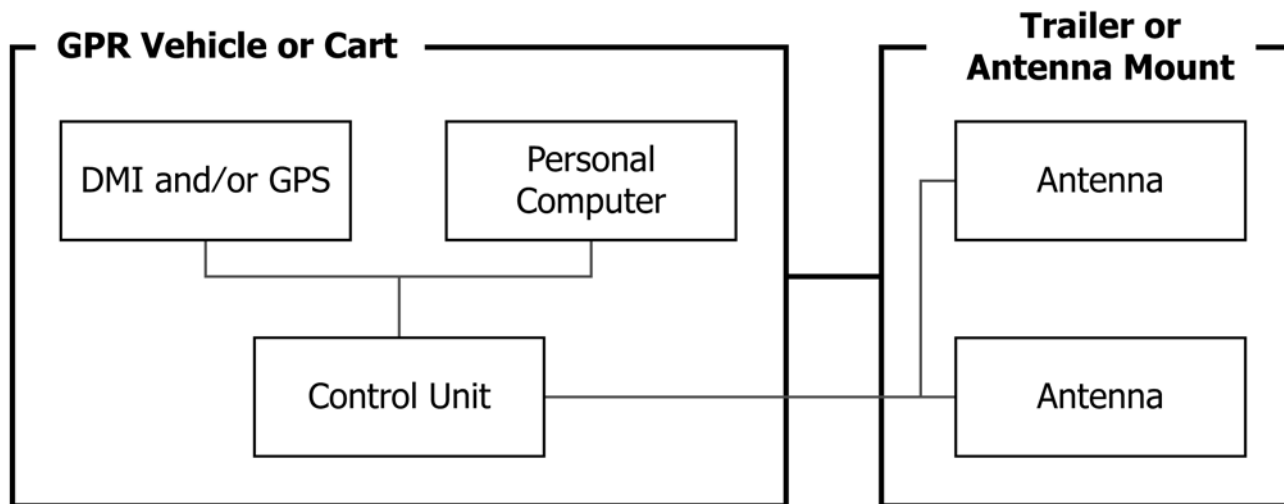


FIG. 1 Equipment Configuration