Nondestructive measurement of layer thickness with the MIT-SCAN-T2

MIT reflector handbook

for MIT-SCAN-T2 customers

Issued April 2013

ZERSTÖRUNGSFREIE MESS- UND PRÜFTECHNIK

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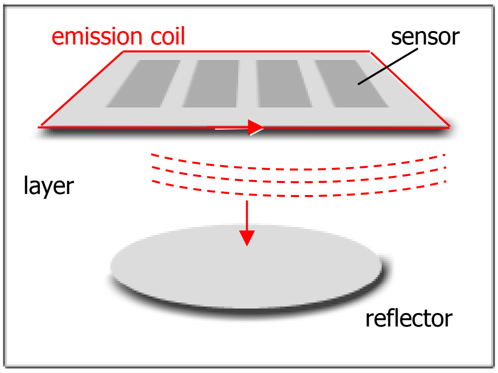
1. Introduction

The electromagnetic method of determining layer thickness provides nondestructive, accurate and cost-efficient measurements of the thickness of concrete and asphalt pavement layers on roads and circulation areas. These are important data required for construction accounting and for ensuring the quality and longevity of pavements. This method is described in the German technical standard TP D-StB 12.

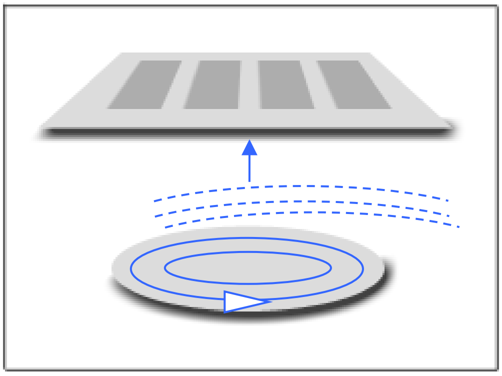
A prerequisite for conducting electromagnetic thickness measurements is the installation of **reflectors**. The electromagnetic method of measuring the layer thickness is therefore used when roads and circulation areas are newly constructed or when pavements with previously installed reflectors are restored or reinstated. The selected measurement reflectors and placement instructions are generally given in the tender documents or defined by the site management for the purposes of self-supervision and inspection.

The measuring technique is based on the principles of magnetic tomography. The layer thickness is determined by analyzing the eddy-current-induced magnetic field emitted by an aluminum or galvanized steel reflector in response to a pulsed magnetic field (emission field).



emission field

An antipole (**reflector**) has to be inserted into the layer to be measured before it is installed. The pulsating magnetic field induces eddy currents in the reflector that decay exponentially and in turn generate a time-dependent magnetic field: the so-called **response field**.



response field

From the response signal, the **MIT-SCAN-T2** calculates the value of the layer thickness, which is then displayed to the user in mm or cm.

1.1. Selected reflectors

The **MIT-SCAN-T2** measuring device and the reflector at the specific measuring site form a coherent system. The device is calibrated by the manufacturer before delivery so it can be used with all commonly available reflectors. It covers the entire measurement range and general applications in the field. Commercially available reflectors differ with respect to dimensions and material. Currently used reflectors are made of aluminum or galvanized steel and are usually either circular (plates), square, or rectangular (sheet metal or foil). The German test regulations for thickness measurements in road works (TP D-StB 12) specify that reflectors for control measurements must be installed securely according to a layout plan. For self-monitoring purposes, the reflectors may also be placed directly in front of the paver without fixation.

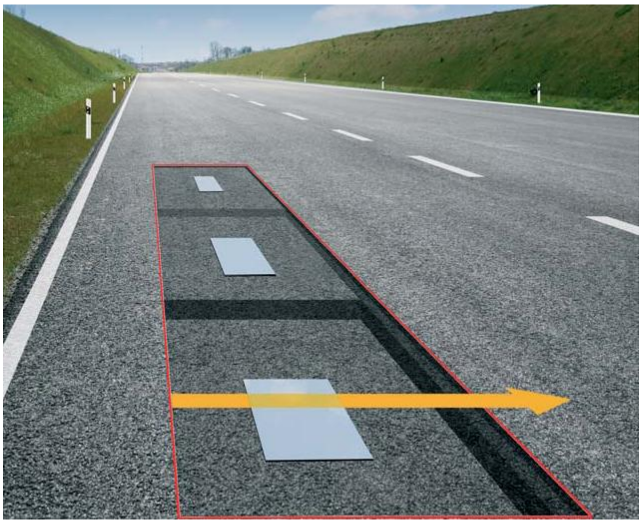
Circular plates: These can be easily installed. They are robust against accidental damage during installation and thus ensure highly precise measurements. The direction of the measurement path over the reflector can be selected randomly thus enabling measurements to be performed also under unfavorable conditions (e.g. directly next to curbstones). Circular aluminum plates must be fixed securely with an adhesive, whereas circular steel plates can be fixed with a stainless steel nail.

Sheet metals: These are used for measuring layer thicknesses of > 35 cm (e.g. frost protection layers, unbonded layers). When sheet metal formats are used, minimum cover requirements must be observed. Rectangular sheet metals should be installed parallel to the direction of traffic and passed over perpendicular to their long sides.

Foils (made of aluminum): These are available in various formats. Ready-made formats are preferable to those cut from a roll because inaccurate trimming may produce incorrect formats. Rectangular foil formats should be installed parallel to the direction of traffic and passed over perpendicular to their long sides.

Thin foils ≤ 40 µm have proved to be disadvantageous for this measuring technique. They are damaged during installation and produce unreliable measurement values. Thin foils also tend to disintegrate completely within a relatively short time so that the respective measuring site is later not available (e.g. for inspection of existing roads). It is strongly recommended not to use foils that are too thin. Please find a picture of a damaged thin foil as shown below:

Please note: The technology requires the use of ≥ 100 µm thick foils. The following image shows a schematic representation of a measuring site. Rectangular reflectors are passed over perpendicular to their long sides. The center of the reflector only needs to be passed over roughly during measurements.

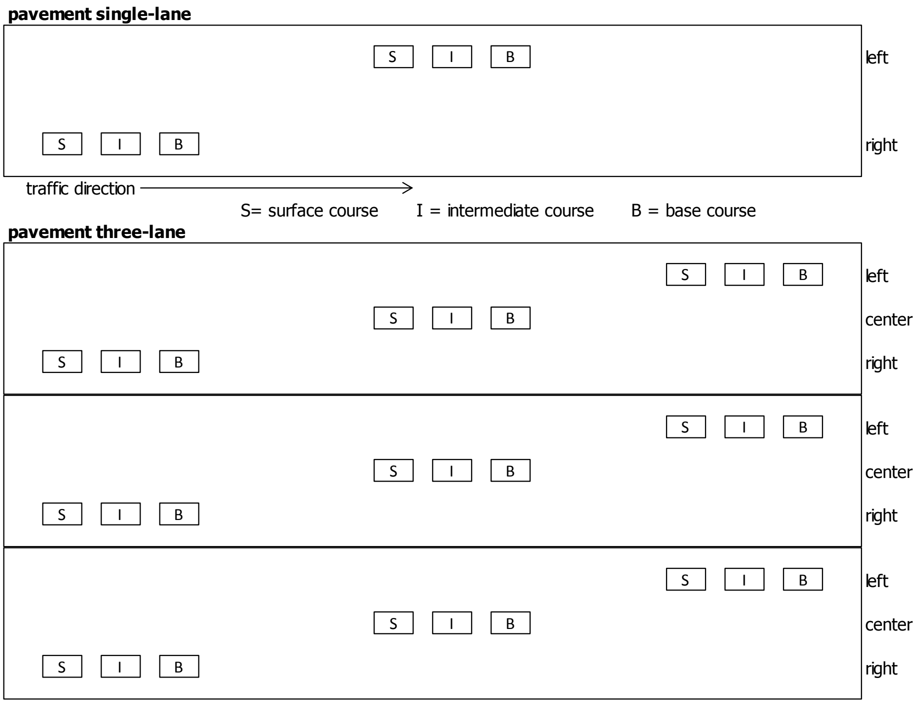


Only robust, customary reflectors that have been certified for use with the measuring device should be used at construction sites.

Attention: Before starting a measurement, the type of installed reflector must be selected on the device and set up correctly. If the user overlooks this step, plausible results cannot be expected (operator error).

1.2. Setting up a measuring site

The layout drawing specifies the type and number of reflectors to be used and their location/position in the road. Example of a reflector layout plan in an asphalt roadway:



A measuring site comprises all the reflectors that are necessary to analyze each composed layer at one location in the roadway. The respective reflectors are placed beneath each of the layers to be measured. Technically correct placement of measurement reflectors requires that an influence of **extraneous metals** on measurement signals is excluded. The **minimum distance** of 1 m between reflectors and 1.5 m between reflectors and built-in road fitments, such as storm drains or concrete reinforcements and dowels, must be maintained at all times. The measuring site is usually marked on the side of the road.

Each individual layer thickness value is to be measured as specified under ZTV Asphalt-StB 07 at measuring sites spaced out at regular intervals across the construction area. Accordingly, the lengthwise space that is to be kept as a rule is 50 m between measuring sections. However, no less than 20 measuring sites are required for data acquisition. In roads with widths up to 5 m, the measuring sites are arranged alternately right and left (in a zigzag pattern). The distance between measuring sites is 20 m in short construction sites (length about 500 m) and 50 m in long construction sites. In multilane roads, three measuring points are arranged in the right, middle, and left lanes so that they form a straight line that is perpendicular to the edge of the road. This provides a sufficiently high statistical reliability for evaluating the construction performance. However, the contracting party and the construction company may agree upon arrangements that deviate from the regulations if required in specific situations.

The **minimum cover** specifies the material thickness that must at least be installed between the reflector and the surface of the completed pavement.

2. MIT circular plates

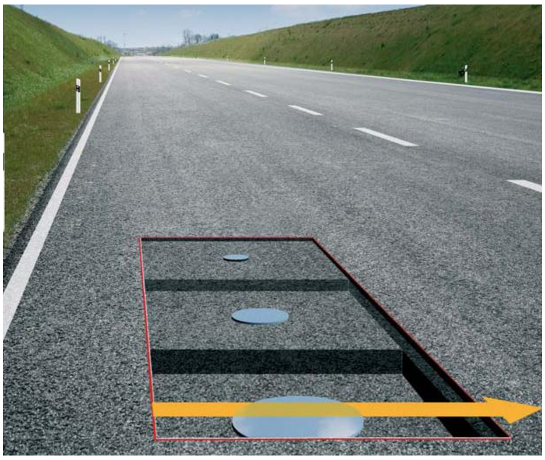
Circular plates of aluminum are used for measuring layer thicknesses during asphalt road construction. Circular plates of galvanized steel are mandatory in concrete pavements.

2.1. Aluminum circular plates for asphalt pavements

In Germany and the European Union, layer thickness measurements of asphalt pavements are compulsory (cf. ZTV Asphalt-StB 07 in conjunction with TP D-StB 12, EN 12697-36, RVS 11.03.21). The respective measuring sites are equipped with circular aluminum plates or aluminum foil for self-evaluation or external inspection purposes. However, because aluminum foils can be severely damaged during placement, such measuring points may become unusable for later measurements.

MIT circular plates are not only mechanically robust, and thus technically reliable, but are also easier to install. Their electromechanical properties barely change in relation to temperature variations. Installation of hot asphalt paving therefore has no effect on reflector properties. The layer thickness of asphalt pavements can be determined with high precision directly behind the paver or after compaction whilst they are still hot.

Asphalt roads consist of several layers. Each layer has a different thickness and material composition (grain size/sieve grading curve). To monitor the layer build-up, the thickness of each layer is measured individually. For an entire road layer structure, three differently sized circular plates are used. The installation of circular metal plates results in a slight weakening of the interlayer bonding. The smallest possible circular plates should therefore be installed in the uppermost layer (binder and surface layer); see the reflector data sheet/ manufacturer recommendations. The strength of the measured signal decreases with increasing depth. For this reason, larger reflectors are used in deeper layers.



MIT circular plates can be easily fixed with adhesive. The MIT offers a special two-component adhesive, which is easy to use and has no influence on the measurement.

Mechanical requirements:

Reflector	Diameter	Thickness
AL RO 07	7 cm ± 0.1 mm	1.00 mm ± 0.05 mm
AL RO 12	12 cm ± 0.1 mm	1.00 mm ± 0.05 mm
AL RO 30	30 cm ± 0.1 mm	0.50 mm ± 0.05 mm

Aluminum circular plates are produced according to the European Standards EN AW 5754 (Al Mg 3) H111 EN 485/573 from sheet metal (US ASTM Standard 5754).

2.2. Steel circular plates for concrete pavements

The current German TP D-StB 12 regulations have taken account of the requirements given in the standards DIN EN 12 697, Part 36, DIN EN 13 863 Part 1, and DIN EN 13863 Part 3.

Only galvanized steel reflectors are permitted in concrete road constructions because the reflectors can be destroyed prematurely by chemical reactions occurring between the aluminum and the alkaline concrete material.

The electromagnetic properties of ferromagnetic materials and magnetic susceptibility are highly temperature-dependent. Circular steel plates are therefore not suitable for use in asphalt pavements.

For roads constructed of concrete, the total roadway thickness is of interest. Therefore, circular steel plates with a diameter of 30 cm are sufficient for a layer thickness up to 35 cm.

The following picture shows the middle of a slab with a 30 cm circular steel plate that is to be installed at a distance of 2.50 m from the reinforcements in the concrete pavement:

Please note: For concrete placement, the circular steel reflector can be secured to the road underground with a hardened stainless steel nail (diameter: max. 3 mm, length: max. 50 mm).

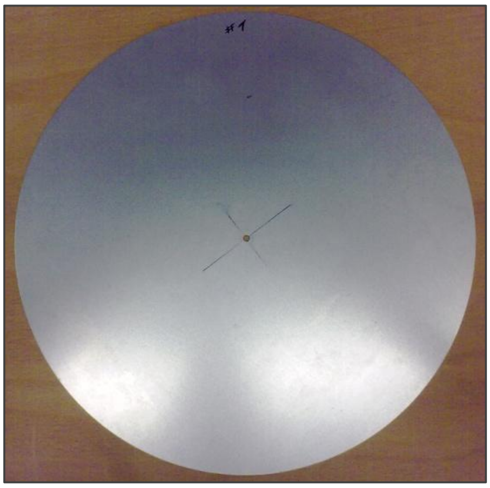


Figure: Example of a circular plate with a drilled hole for the stainless steel nail.

Mechanical requirements:

Reflector	Diameter	Total thickness
ST RO 30	30 cm ± 0.1 mm	660 µm ± 10 µm

Coating thickness on each side: 25 µm ± 2 µm

The selected steel sheet metal complies with the European Standards DIN EN 10142/ EN 10143, incl. WAZ 2.2 (US ASTM Standard A653 Type 2 Commercial 1 Grade, G90).

The reflectors are surface-coated by steel strip galvanization, the Sendzimir galvanization process (continuous hot-dip galvanization).

Figure: Example of a circular Sendzimir-galvanized circular steel plate