Thickness measuring device

MIT-SCAN-T2

Description of the method

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1. Introduction

The non-destructive testing system is a cost-efficient method that delivers accurate thickness measurements on asphalt and concrete road and traffic circulation area pavements. It provides important data necessary for the calculation of construction costs as well as to ensure the quality and life span of the road pavement.

For electromagnetic layer thickness measurements to be carried out reflectors have to be inserted into the pavement. The electromagnetic layer thickness measurement method is thus used when new roads/circulation areas are to be constructed and when road pavements are renewed where reflectors are already inserted.

All types of surfacing material used in building and road construction works - bituminous composites, concrete or blast furnace slag - can be tested non-destructively with the MIT-SCAN-T2.

The innovative technical solution in non-destructive measurement technology offers a tool for combining quality assurance with profitability. The new technology provides the chance to optimize construction practices and to cut costs in the execution of construction works.

The technology used in the MIT-SCAN-T2 is protected by different patents.

2. Principles of operation

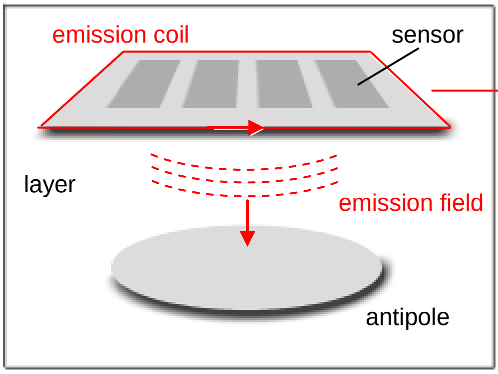
The thickness testing device MIT-SCAN-T2 uses a pulsed induction method based on electromagnetic eddy current technology. This technology has a high noise immunity. The possibility to acquire data for several physical parameters in one measurement operation improves the quality and validity of the measurement results.

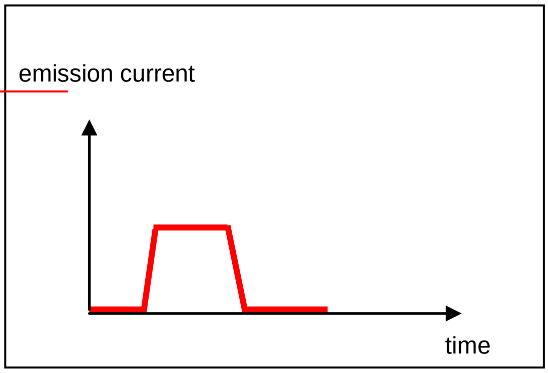
Measurement data are collected by a defined pass over the reflector. During one run, while the reflector is passed over, up to 150 position-dependent measurement points are collected by each of the four receiving sensors. The signals received depend on the relative position of the instrument to the reflector as well as the shape, size and material composition of the latter. The relationship between each of these influences and the measurement signal are precisely determined during calibration and implemented in the firmware of the instruments.

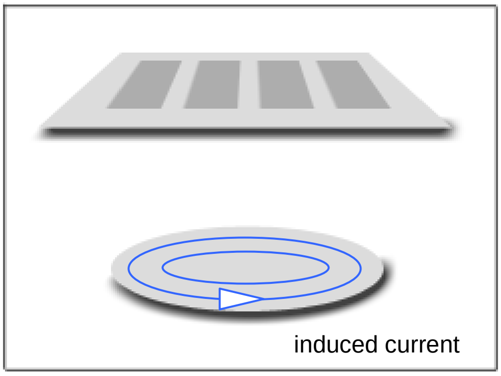
Due to the high number of individual measurement points assessed, the accuracy achieved is superior to that obtained by other methods.

In the following figures a schematic illustration shows the physical order of signal generation. Schematic illustration of signal generation

In the measurement sensor there is a current-traversed transmission coil. It generates a time-dependent magnetic field (emission field) that penetrates the pavement layer.

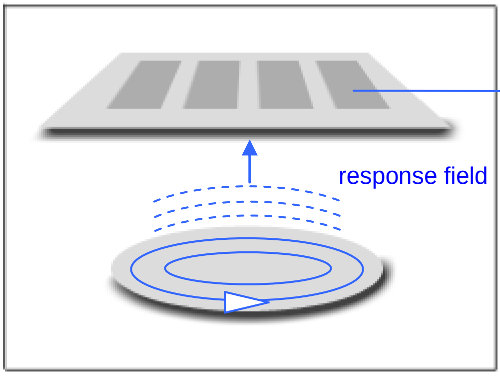


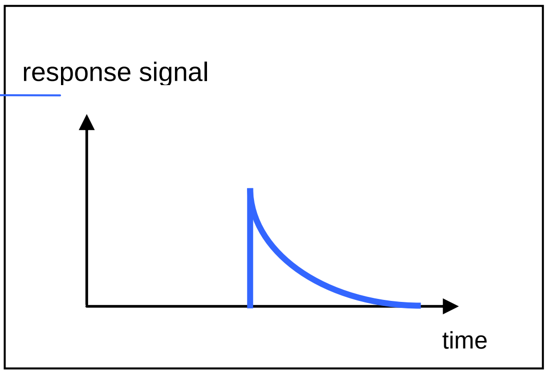




At the bottom of the layer is a reflector (a foil or circular plate of metal). The pulsating magnetic field induces eddy currents in the reflector which subside exponentially and in turn generate a time-depen-dent magnetic field: the so-called response field.

In the measuring probe there are several sensors that assess the response field in its time course.





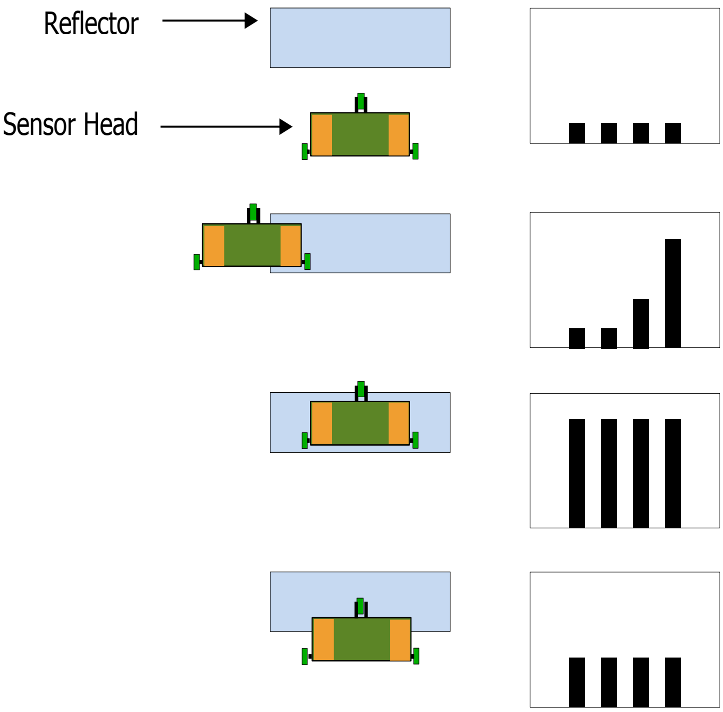
The emission field is generated by alternatingly switching the current on and off in very short intervals (in the range of a few microseconds). Once the emission field has completely subsided the response field is measured. In this way an overlap of the response signal and the comparatively strong emission signal is avoided. The emission signal does not cause disturbances. Even very weak response fields can be detected so that a high operating range is realized by this method.

3. Performing a measurement

Search mode

By pressing the search button a continual readout mode for all sensors is activated. The result is displayed as four vertical bars. The length of the bars correlates to the distance of the respective sensor from the reflector. By moving the measuring probe a few centimeters above and along a 2 m wide corridor the reflector can be located. In the figures below the bar diagram on the display and the position of the reflectors and the measuring probe are shown schematically.

Schematic illustration of the display image and the position of the reflector and the measurement probe to one another.



Measurement

Before starting a measurement, information on the type of reflector used must be correctly entered, because the algorithms applied for calculation of layer thickness are dependent on the reflector type. A measurement is performed by passing the device over the reflector. Rectangular reflectors are passed over perpendicular to their long sides. Since the analysis result also contains the lateral position of the reflector, it is not necessary to exactly determine the reflector center. It need merely be detected within a corridor of about 10 cm width. The testing device is positioned in such a way that it is about 10 cm from the front wheel and the reflector long side. By pressing the measurement button the measurement is started. Measurements are started to be taken by moving the probe in the direction of the reflector. The device is path-controlled and acquires measurement points at intervals of about one centimeter for each sensor while it is moved along the surface of the layer that is under investigation. During measurement, starting from the left, a diagram is created on the display. It shows the calculated average of all four sensor values. In this way, information regarding the measurement situation is provided during the test run. The measurement run is automatically stopped when a distance of approx. 1.5 m has been covered. The measurement result is calculated in maximally one second and shown on the display.

Handling of measurement results

The measurement results can be manually written into a protocol. However, the whole data set can also be saved and is available as a readout on the display, ready for printing on a pocket printer at the construction site or data can be transported into a PC until it is deleted from the memory.

Assessment of the measuring site

If an unexpected measurement is determined, according to our experience the cause usually is a defect of the foil reflector (deviation of dimension, destruction of the foil). Therefore, provision has been made for determining the length and width of the reflector as well as the material coefficient F. This should be accomplished immediately after the depth measurement has been carried out by passing over the foil reflector twice - once in perpendicular and once in parallel to its long axis. F is a value calculated from the thickness of the material and electrical conductance. The coefficient can be evaluated by means of a provided table.

4. Assortment of reflectors

The choice of reflector material is dictated by where the reflector is to be placed (concrete or asphalt), while the reflector type (sheet metal, foil, and dimension) determines the position of the reflector in the layer and the maximum layer thickness that can be measured. It is important to meet requirements on the minimum surfacing layer when using sheet metal formats.

Only those reflectors that have been implemented in the firmware by MIT and which are mentioned in the operating manual can be used.

MIT recommends the use of the circular plates for the following reasons:

- The circular plates are easily inserted; in general they are placed directly in front of the paver without adhesives.
- The circular plates are robust against incidental damage during installation and thus ensure high precision measurements.
- The direction of the measurement path over the reflector can be chosen randomly. This enables the taking of measurements also under unfavorable conditions.
- The circular plates can be produced at a low-cost.

Table of MIT-circular plates:

Designation	**Application area**	**Layer type**	**Min. surfacing layer**	**Measurement range**
AL RO 07	Asphalt	Surface course	15 mm*	15 - 120 mm
AL RO 12	Asphalt	Binder	40 mm	15 - 180 mm
AL RO 30	Asphalt	Base	120 mm	40 - 350 mm
ST RO 30	Concrete	Subconcrete	120 mm	40 - 350 mm

*) when plastic aggregates are used, otherwise 20 mm

Minimum surfacing layer: The minimum surfacing layer is the thickness of the material from the reflector to the road surface on a completed road construction.

5. Laying plan

The laying plan determines the type of reflector to be used and its position in the road. The following rules should be observed:

1. Testing site
The testing site should include all reflectors necessary to measure all constructed layers in one road location (maximally three reflectors).
The reflectors are placed under the layer that is to be tested. Rectangular reflectors are placed with the long side parallel and 1 m from the road border. The reflectors for the different layers are placed in direction of construction with a minimum distance of 1 m between them. For implementation of these laying rules it will be necessary to make exact side markings. There should be no other metals within 1 m of the testing site and the individual sensors.

2. Arrangement of testing sites
The number and arrangement of the testing sites on the road depends on the length of the construction section and road width. For roads up to 5 m width, the test points are arranged alternatingly to the left and to the right (in zig/zag). The distance between test points for short construction sections (length about 500 m) is 20 m and for long sections, it is up to 50 m. In multi-lane roads the three test points are arranged right, middle and left in one line perpendicular to the road border.

The arrangements given for the test points provide a sufficiently high statistical assurance regarding evaluation of construction performance. The client and the construction firm may agree on other arrangements if the individual situation requires deviations.

6. Technical specifications

Application conditions:

Distance between reflectors:	1 m (edge to edge)
Distance to crash barriers or similar:	1 m
Distance to parking vehicles:	2 m
Operation temperature:	-5°C to 50°C (23 °F to 122 °F)
Storage temperature:	-10°C to 50°C (14 °F to 122 °F)
Asphalt temperature:	up to 110°C (230 °F)

Any foreign metallic objects must be removed from the road lane. Safety boots with metal caps can cause disturbances, if not used appropriately. Wet roads or weakly conducting and magnetic aggregates do not cause erroneous measurements.

Antipoles and depths:

Aluminum foils and aluminum sheets (for asphalt):

100 x 30 cm and 70 x 30 cm	for depths up to 50 cm
60 x 30 cm and 50 x 30 cm	for depths up to 45 cm
33 x 33 cm	for depths up to 42 cm
16.5 x 16.5 cm	for depths up to 30 cm

MIT-circular plates:

Aluminum circular plates	d=7 cm, d=12 cm, d=30 cm (dephts, please s . table page 7)
Steel circular plates	d=30 cm (dephts, please s. table page 7)

Tolerances:

Resolution:	0.1 cm
Accuracy:	better than ± (0.5 % of measurement value + 0.1 cm)
Reflector determination:	for rectangular reflectors: Determination of width ± 2.5 % Determination of length ± 1.5 % Detection of too thin or too strongly damaged materials Data logger for further evaluation of the signals on a PC

Memory:	Capacity: 16384 data sets; each data set contains: site, date, time, reflector type and the measured layer thickness; sequential arrangement of data sets
PC interface:	for data transport to PC for data integration into Microsoft Excel, and ElmaDick (an accounting software) data integration into other user application software on request
Pocket printer:	Printout of measurement data and data on the testing site and the on-site reflector
Power supply:	NiMH storage battery 12V/ 2Ah
Operation time per battery charge:	≥ 8 h at the rate of 3:1 for Standby (menu) to Active (search/ measurement)
Charge time:	about 1.5 h
Test device:	about 42 cm x 139 cm x 19 cm (17 in x 55 in x 8 in) Weight incl. battery about 3.0 kg (6.6 lbs)
Carrying case:	87 cm x 45 cm x 26 cm (35 in x 18 in x 11 in)