PUMATRONIX

ITSSENSOR PIEZO

ITSSENSOR PIEZO

SENSOR DE PESAJE EN MOVIMIENTO

Instalación

Pumatronix Equipamentos Eletrônicos Ltda.

Rua Bartolomeu Lourenço de Gusmão, 1970. Curitiba, Brasil

Visit our website https://www.pumatronix.com

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Change History

Date	Revision	Updated content
12/12/2024	0.0	Previous Version
03/10/2025	1.0.0	Initial Edition

Summary

1. Processes to be developed

In addition to the *Inspection of the Pavement* on which the ITSSENSOR PIEZO will be installed, the processes below must be carried out, in the sequence listed and detailed below:

1) Cut in the asphalt for the sensor;
2) Cut in the asphalt for cable passage;
3) Testing, preparation and installation of ITSSENSOR PIEZO;
4) Placement of the temperature sensor in the cut for cable passage (when applying the Class I model, used in Weighing);
5) Closing the cut in the asphalt for the ITSSENSOR PIEZO (using *Resin Cement*);
6) Closing the cut for cable passage in the asphalt (protecting the cables when using elastomer or hot tar).

2. Road Markings for Asphalt Cuts

The process of Cutting Asphalt, Installing Sensors, Passing Cables and Closing the Asphalt must be done on the same day and only after making terminal boxes at the sensor cable exit points so that they can be accommodated after the end of the work! These processes cannot be interrupted. Pay close attention to whether the track is dry and whether there is no rain forecast for the next few hours. If interruption is needed, the cuts must be cleaned and closed with resin.

Note: First, the marking and side installation must be carried out according to the project. Once they are ready, the Pavement must be marked and cut.

To carry out Asphalt Marking and Cutting, ensure that the road is blocked with the appropriate safety equipment, in accordance with local regulations.

To perform this service, the following items and equipment will be required:

- Tape measure of at least 5 meters: For measurement;
- 0.8m square: To ensure the 90° angle;
- Rope or String: To help with marking (use the thickness of the rope as a template);
- Or Template;
- Spray;
- Project.

Note: Before proceeding, check if the sensor markings are positioned exactly perpendicular, forming a 90° angle in relation to the traffic flow, and ensure that all lines are straight.

To begin marking the sensor depth cuts, start at the opposite end of the cable.

Note: Check the project to determine the starting point of the marking in relation to the track strips.

To prepare the markings, we will first start by passing the cables.

1) Mark the Temperature Sensor close to the post, following the precise instructions provided in the submitted project.

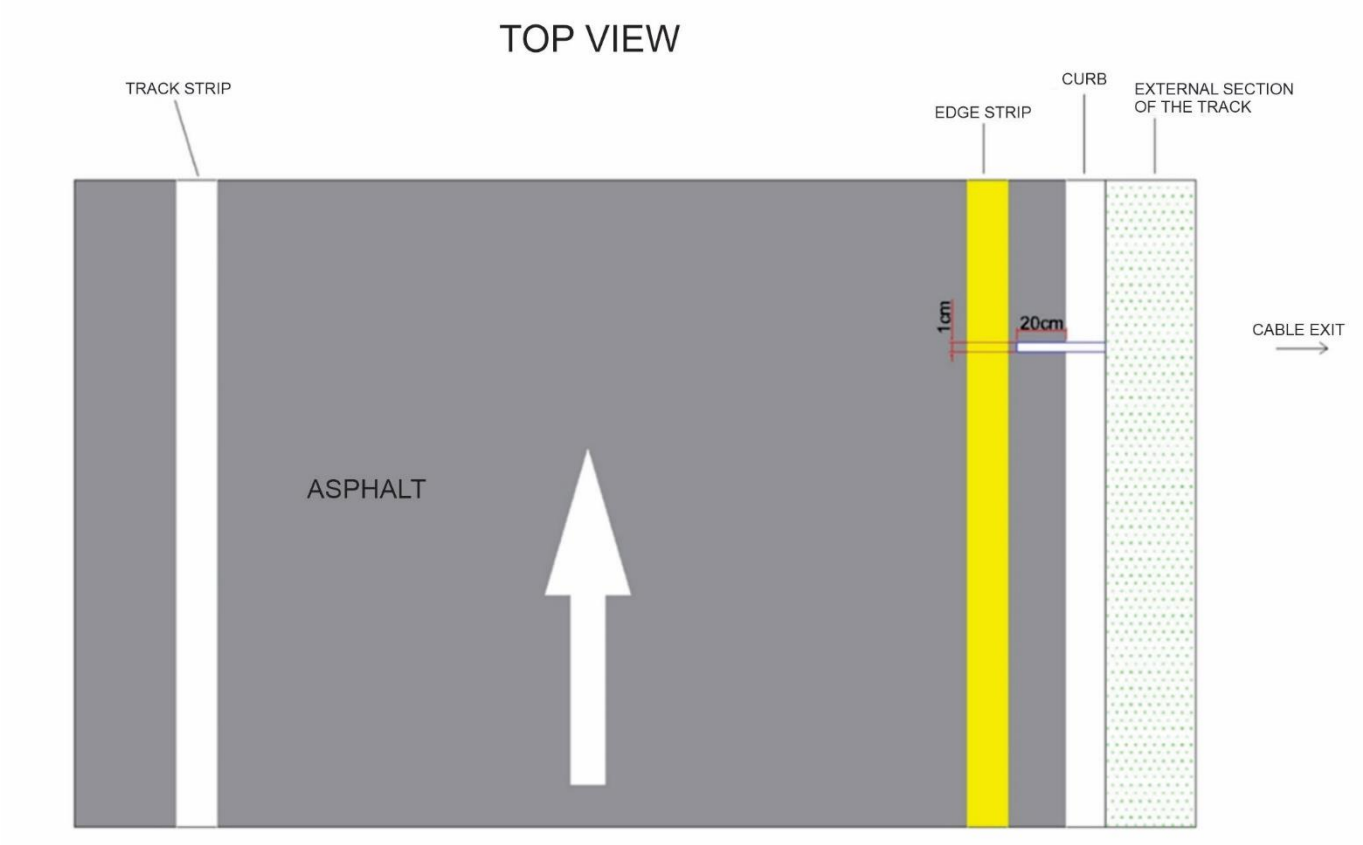


Figure 1

2) Ensure the 90º angle with the square. Position the square on the side or in the center of the track where the track division strip or edge strip is located and place the rope ensuring that it is in a straight line in relation to the square, as shown in Figure 1.

Figure 2

3) Center the Sensor measurement on the track:

Figure 3

4) Stretch the rope or string along the floor in the position where the sensor will be installed.

Figure 4

5) Spray over the rope, using it as a template for cutting.

Figure 5

6) Remove the string and the marking will be as shown in the figure:

Figure 6

3. Cut in the Asphalt for Piezo Sensor

Notes: Perform Pavement Cutting after installing Posts, Boxes, Passage Pipes and Marking the Cuts on the track.

Before starting the cuts, it is essential to ensure that the markings are ready and that the machines required for the process are ready for immediate use:

- Asphalt Cutting Machine
- Impact Hammer
- Air Blower
- Marble Saw or Wall Cutter
- Segmented Diamond Cutting Disc
- Grinding Wheel
- Chisel Tip

CAUTION: The process of cutting asphalt, installing sensors, passing cables and closing the asphalt must be carried out on the same day and without interruptions. Before starting, make sure to make terminal boxes at the sensor cable exit points, so that they can be accommodated at the end of the work. It is crucial to carefully observe whether the track is dry and dry and whether there is no rain forecast for the next few hours. If interruption is necessary, the cuts must be cleaned and closed with resin.

Note: Control the depth with a maximum error of +/- 3mm.

Note: Use the air blower while cutting the asphalt so that you can see the cutting line.

Figure 7

3.1. Cut Width for Piezo Sensor

Note: To ensure accurate cutting width, the discs to be used must be measured after being mounted on the cutting machine. No further tolerance should be allowed in this regard.

Notes: Always use new or pre-owned discs to make cuts.

7) Insert the Recessing Discs into the Cutting Machine.
8) Adjust the Discs so that the cutting width is 20mm.

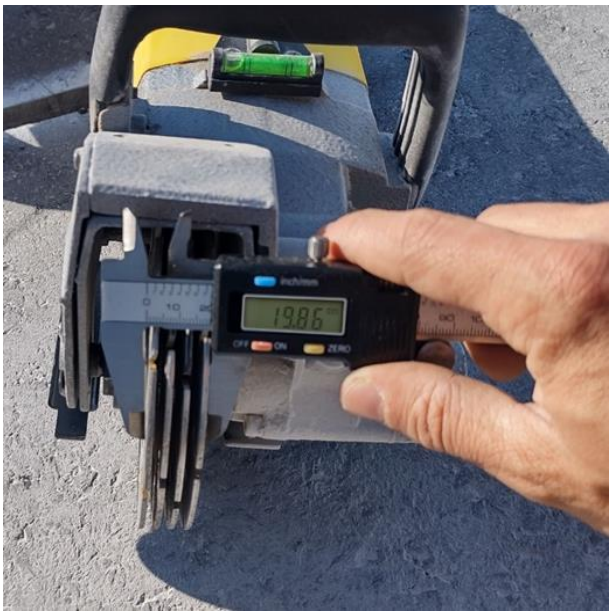


Figure 8

Figure 9

The depth will vary in 4 points according to the marking made.

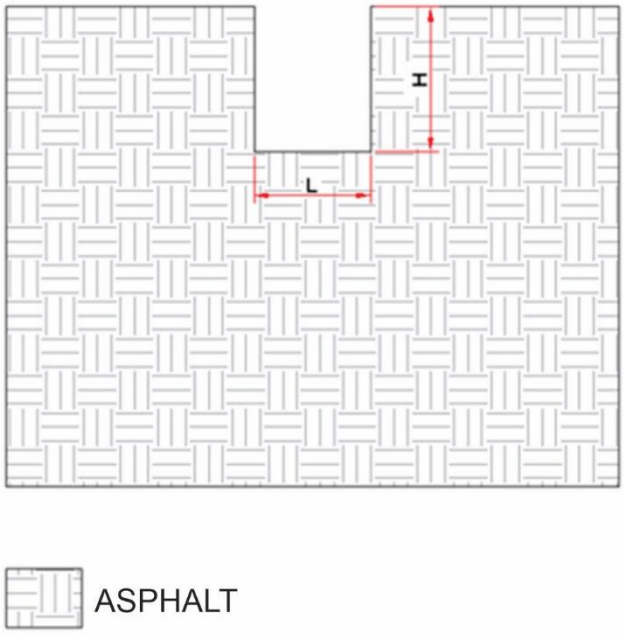
3.2. Cut Depth 1

9) Adjust the Cutting Machine to a depth of 25mm.

Figure 10

Figure 11

10) The cut across the entire length of the sensor area must be made with a width of 20mm and a depth of 25mm.



L = 20mm H = 25mm

Figure 12

11) Make a cut along the (variable) length of the sensor with a depth of 25 mm.

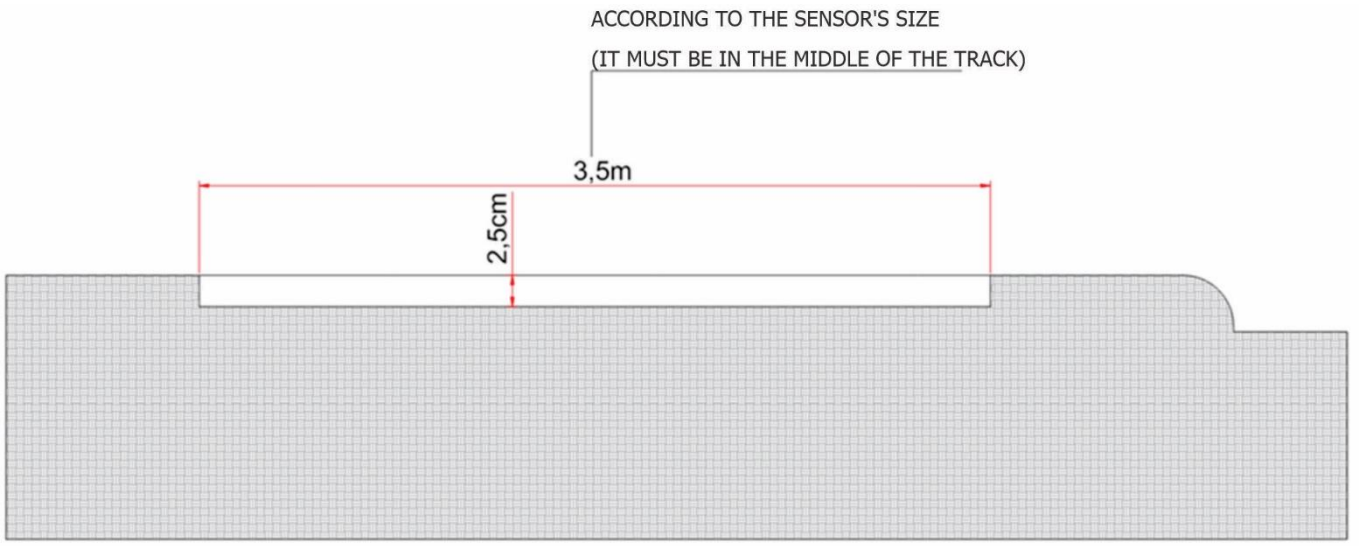


Figure 13

Note: Check that the entire length of the cut is 20 mm wide.

Figure 14

Note: Check that the cutting depth is 25 mm.

Figure 15

3.3. Cut Depth 2

12) After performing Cut Depth 1, perform Cut Depth 2.

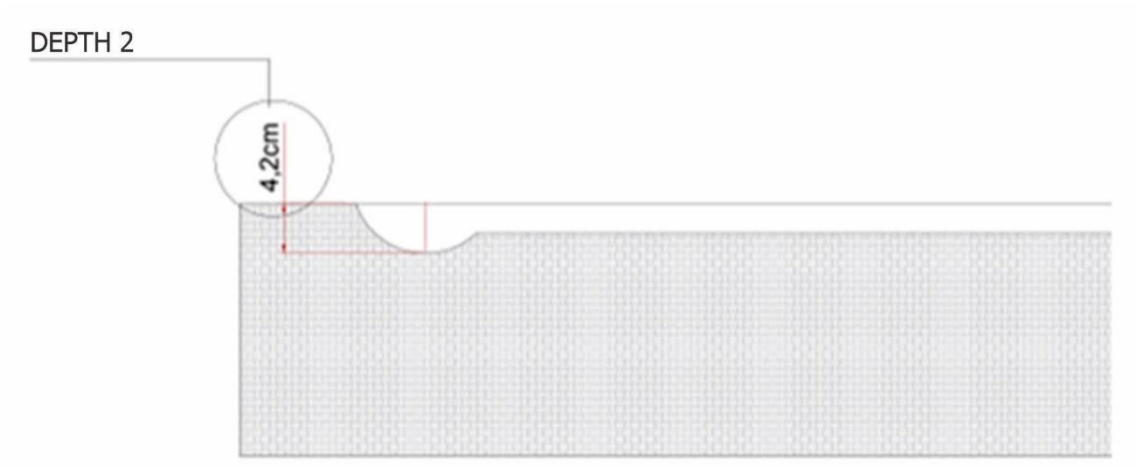


Figure 16

13) Adjust the Cutting Machine to a depth of 42mm. Remove the height limiter support and tilt the machine during cutting.

Figure 17

At the start of the track cutout (sensor tip side) the depth should be 42mm. Place the cutting machine shaft at the end of the sensor measurement to make the recess.

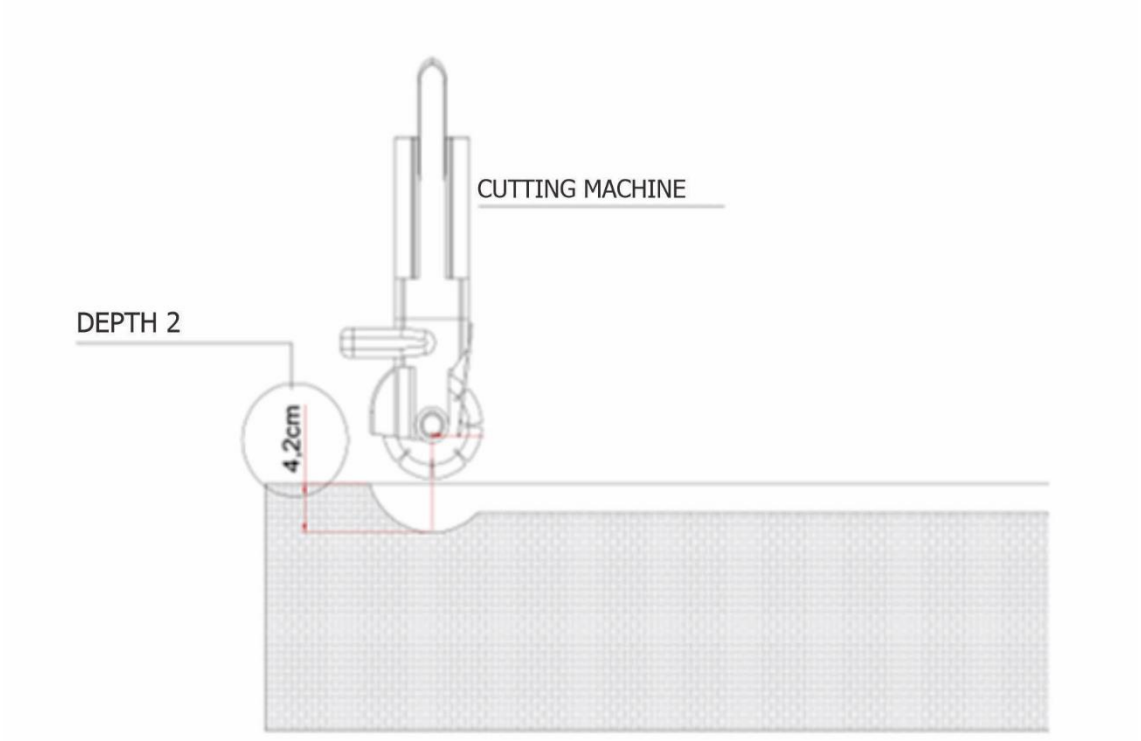


Figure 18

3.4. Cut Depth 3

14) After performing Cut Depth 2, perform Cut Depth 3.

At the end of the track cutout the depth should be 42mm. Mark a distance of 100mm before and 150mm after the final cut to cut with the machine (Total 250mm).

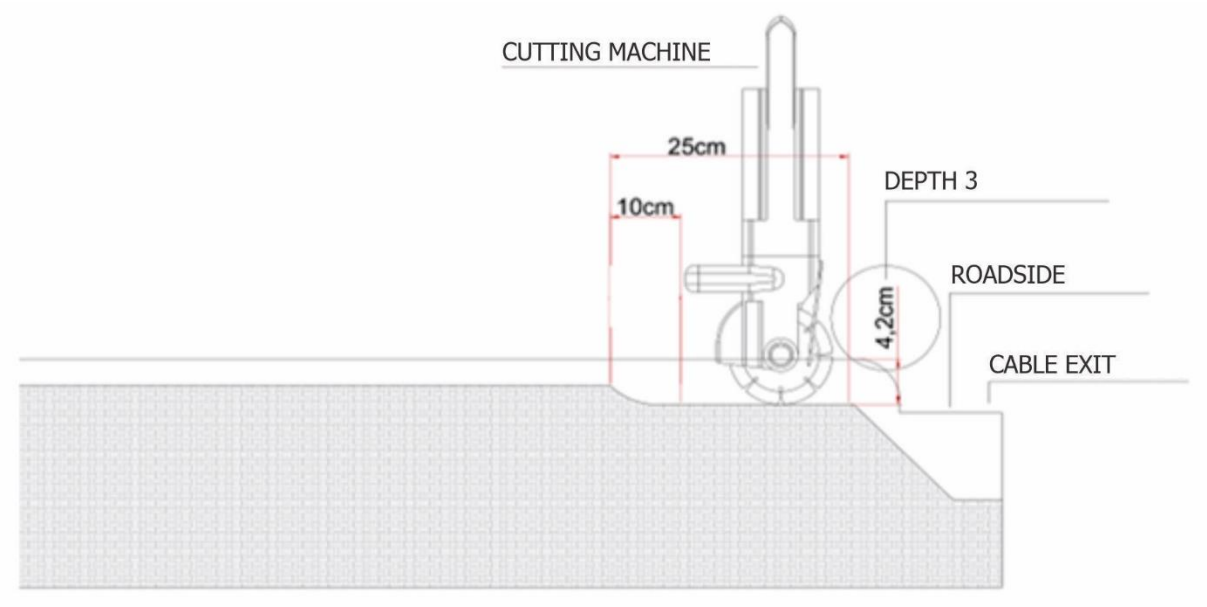


Figure 19

Note: Check that the depth of cuts 2 and 3 are 42 mm.

Figure 20

3.5. Cut Depth 4

15) After performing Cut Depth 3, perform Cut Depth 4.

The cable exit cut must be 80 mm deep into the track or roadside. The width must be at least 6mm for the CUTTING MACHINE/. Check if there are other cables that will use the same exit and adjust the width.

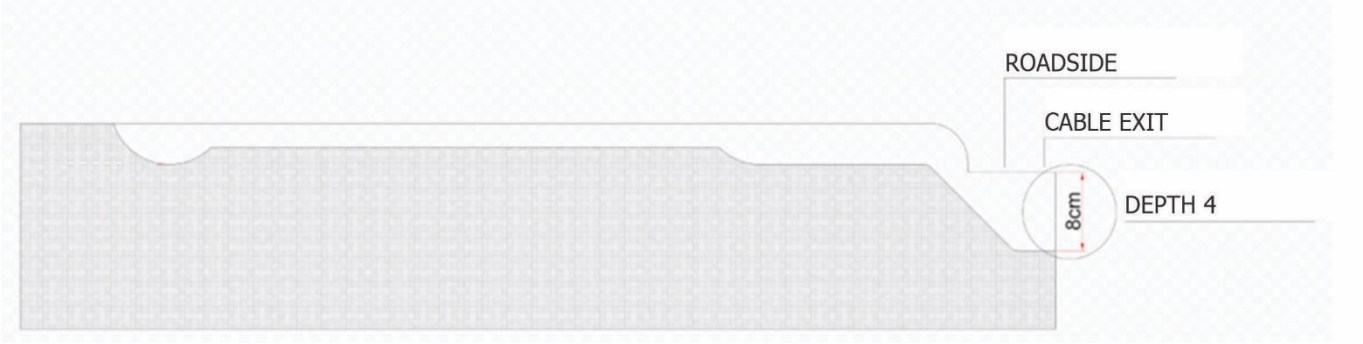


Figure 21

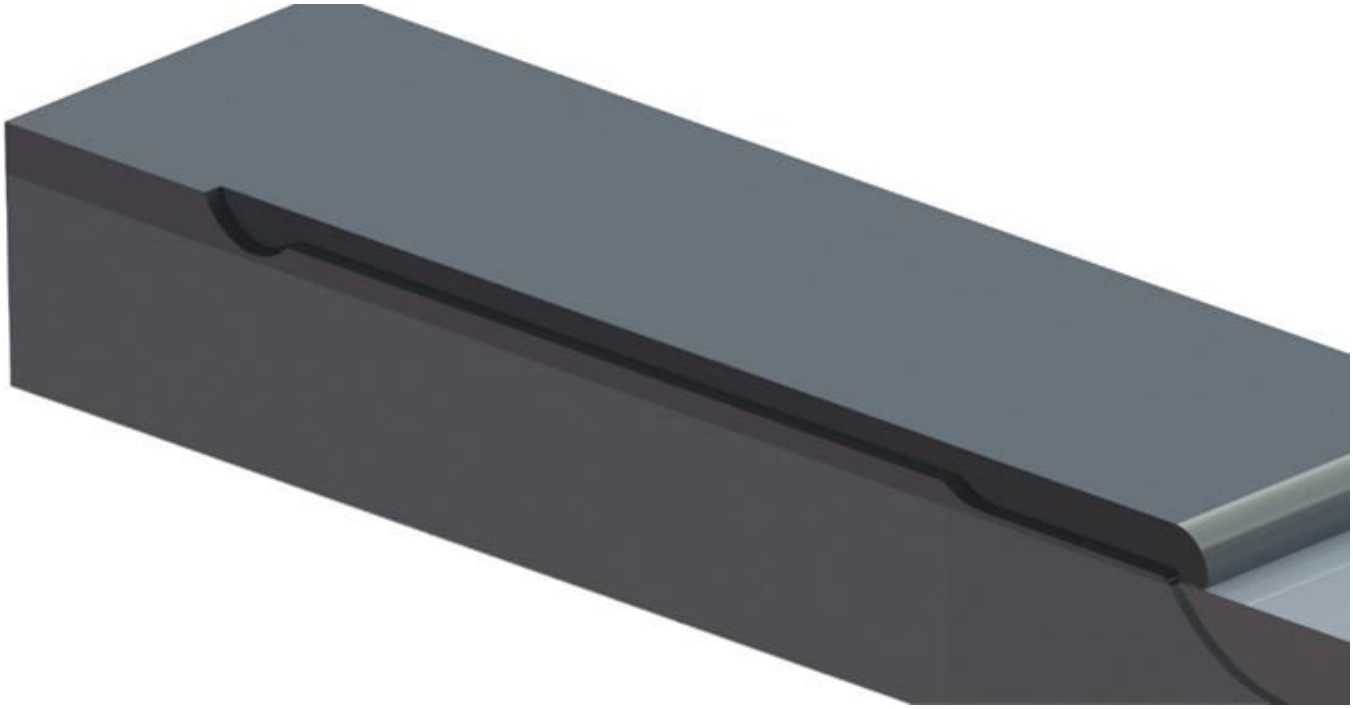


Figure 22 - Image of the finished cut

Note: Use the hammer to ensure the correct depth and angle of the cuts with straight lines as shown in the figures, as well as to remove burrs from the cut.

Figure 23

Figure 24

Figure 25

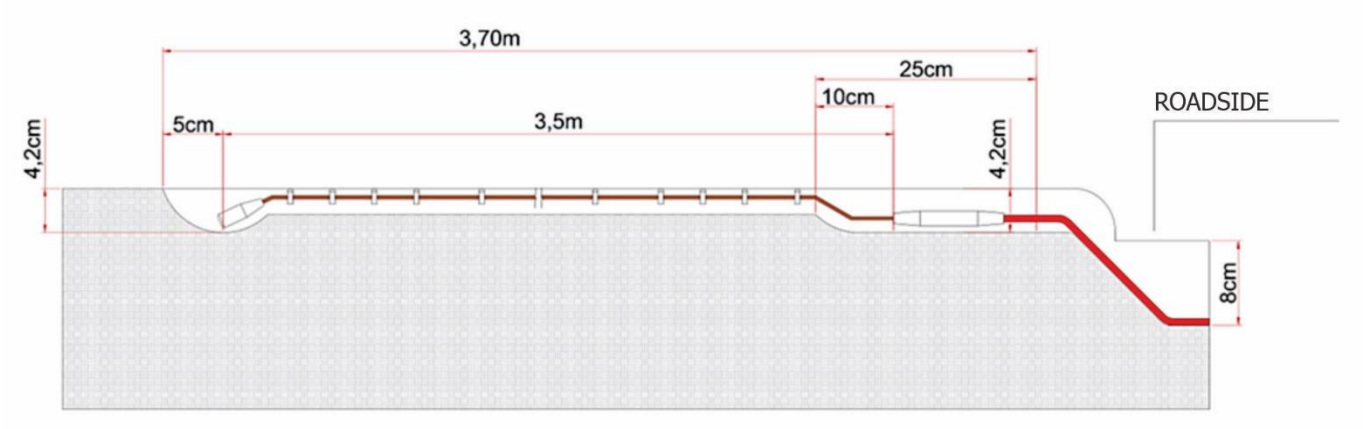


Figure 26

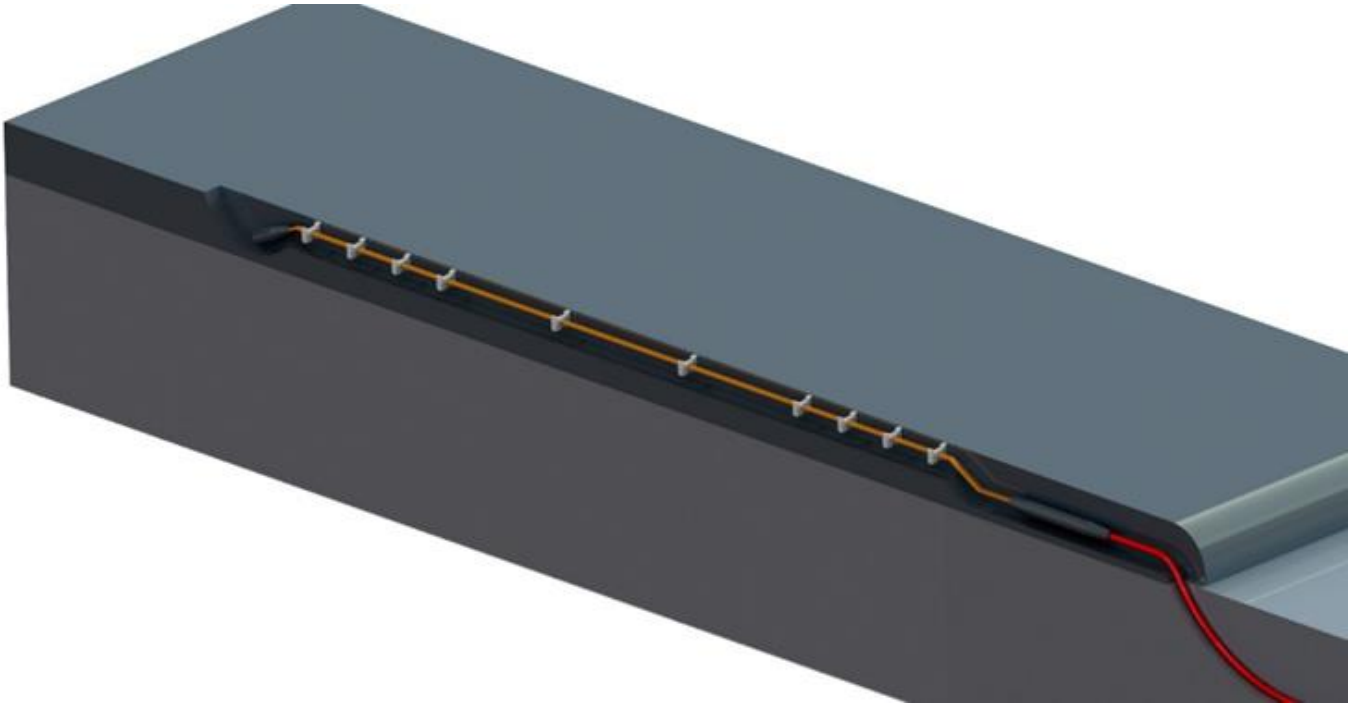


Figure 27

3.6. Finalization of the Cut

To perform this service, the following items and equipment will be required:

- Air compressor;
- High Pressure Washer;
- Brush;
- Steel Brush;
- Barrel with Water;
- Broom;
- Tow;
- Acetone.

3.6.1. Steps for Cleaning the Cut

16) The cuts must be very clean for the installation of the Piezos. Sweep and wash away all debris.

Figure 28

Figure 29

17) Air dry all cuts using a blower or air compressor. Make sure all cuts and the surrounding area are completely dry before proceeding.

Figure 30

Figure 31

18) Use a clean, lint-free cloth soaked in acetone to clean the cut and its sides, completely removing dust and grease. This step is crucial to ensure effective resin adhesion.

Figure 32

3.6.2. Preparing the Cut for Sensor Placement

To perform this service, the following items and equipment will be required:

- 50mm Yellow Adhesive Tape or Silver Tape;
- Scissor.

Cutting Preparation Steps:

19) Stick the adhesive tape along the length of both sides of the cut to accommodate the sensor. The tape must be 50mm wide to avoid contamination of the resin in the asphalt. Leave a 5mm margin from the edge of the cut.

It is crucial to ensure that the tape does not fall inside the cut.

To apply Adhesive Tape, use gloves.

DO NOT walk over the cut to avoid accidentally dropping dust or dirt into the opening or sides.

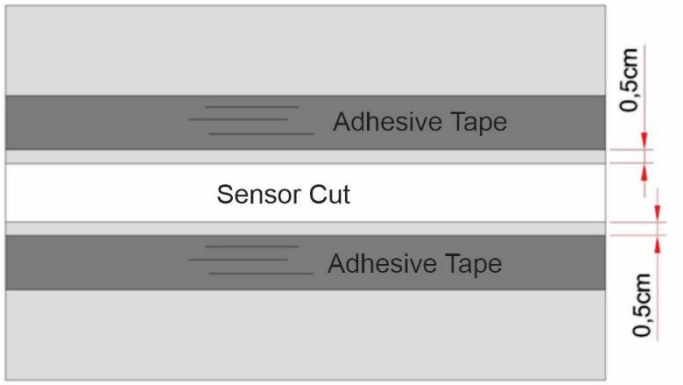


Figure 33

Figure 34

Figure 35

4. Cut in the Asphalt for Cable Passage

Note: Perform Pavement Cutting after installing Posts, Boxes, Passage Pipes and Marking the Cuts on the track.

To start cutting, the markings must be ready and the machines involved in the process must be in hand.

20) Insert the cutting disc into the Cutting Machine.
21) Make the cut in the pavement, according to the project, up to the terminal box installed on the Side of the Track.

- **Thickness:** it should be 10 to 12 mm thick, so it must be cut again with a 6 mm disc to achieve this thickness or use 2 6 mm cutting discs.
- **Depth:** should be 60 to 100mm.

If it is necessary to pass more than one length of cable from another reel, check the depth in the project.

Figure 36

Figure 37

5. Tests Before Preparing the Piezo Sensor

To perform this service, the following items and equipment will be required:

- Digital Multimeter
- BNC Connector/Terminal CNC00035

5.1. Visual Inspection of the Sensor

The test must be done with the Sensor in the box and before installation.

22) Check that there are no exposed wires on the Sensor cable.
23) Check for cracks or gaps in the Sensor cable connection.
24) Check if the Sensor's flexible cable is long enough to reach the cabinet.
25) Check that there are no bends in the Sensor.

5.2. Capacitance Test

The test must be done with the Sensor in the box and before installation.

26) Use the Digital Multimeter to measure the capacitance across the sensor.
27) Measurements must be within the range as per the data sheets that accompany each Sensor.
28) Set the Capacimeter to the 20nF range.
29) Insert the Female BNC connector into the male BNC connector of the sensor cable.
30) Insert the red test lead of the Capacimeter into the "+" of the Female BNC connector and the black test lead into the "-" of the Female BNC connector.

Pay attention to your hands. Make sure they do not touch metal parts when measuring.

31) The result must be less than 20nF.

Figure 38

5.3. Endurance Test

The test must be done with the Sensor in the box and before installation.

Pay attention to your hands. Make sure they do not touch metal parts when measuring.

Perform the Resistance Test with the Sensor stable. Avoid any type of vibration on the surface and the Sensor during the test.

32) Use the Digital Multimeter to measure the resistance across the sensor.
33) Set the Multimeter to the 20MΩ range.
34) The reading table should be greater than 20MΩ (open), usually shows with "1" or "0L" to indicate correct measurement.

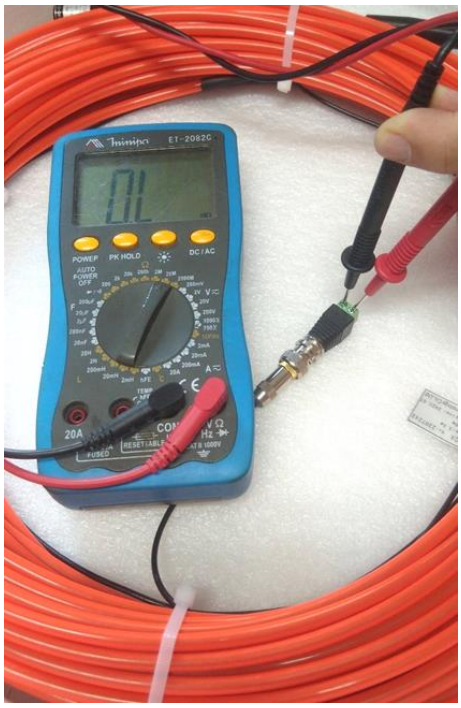


Figure 39

6. Piezo Sensor Preparation

Storage and Transport:
Fragile: Keep the Sensor in the original box. Do not put weight on top. Maximum stacking of Sensor boxes: 10.
Humidity: Do not leave exposed in a humid environment.
Impact: Do not hit or throw the Sensor.

Handling:
It must be done using a plastic glove.
Do not bend the Sensor area.
Do not hit or throw the Sensor.

Two employees will be needed to prepare the Sensor that will be installed.

To perform this service, the following items and equipment will be required:

- Rigid ruler 2 to 5 meters
- Tape Measure 50 and 5 meters
- Tow
- Acetone
- Disposable Glove
- Permanent Marker
- Brackets

35) Carefully unroll the sensor, ensuring that it is completely straight and without any bends or deformations.

Figure 40

Figure 41

36) Using a lint-free cloth and acetone, clean the entire sensor operating area.

The Sensor must be turned so that the curvature at the ends (due to it being rolled up) is facing downwards before being folded. Note that in the Figure below the end of the Sensor is slightly curved upwards, in this case, the curvature should be turned downwards.

Figure 42

Figure 43

6.1. Sensor Folds

Bend the ends of the Sensor according to details A and B in the figure below (see the following procedures).

Do not bend the Sensor beyond the specified. At the risk of damaging it.

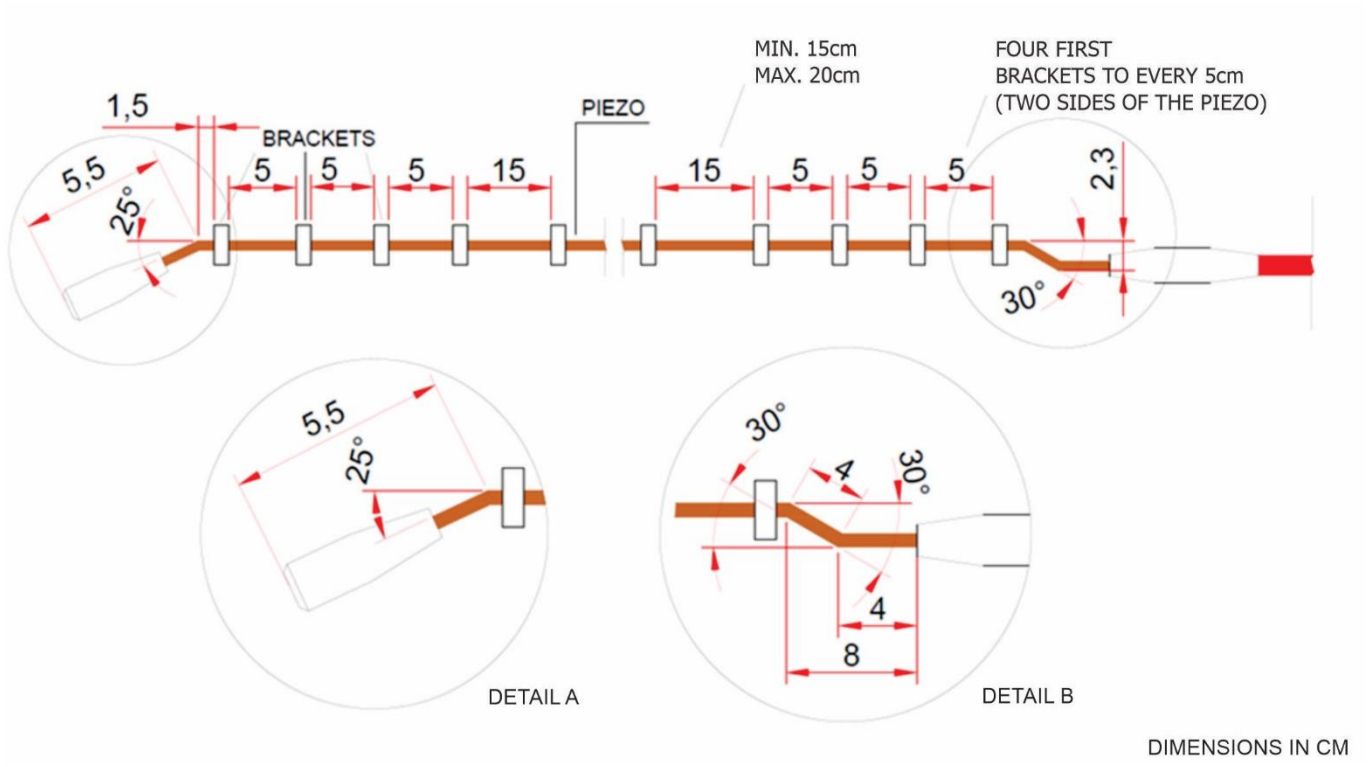


Figure 44

6.1.1. Bending the Opposite End of the Cable

37) Measure 65mm from the end and mark with a permanent marker:

Figure 45

38) Perform the 30° fold:

Figure 46

6.1.2. Cable End Bending

39) Make two markings, one at 40mm and the other at 80mm from the Sensor Cable:

Figure 47

40) First, make a 30° fold at the 80mm mark:

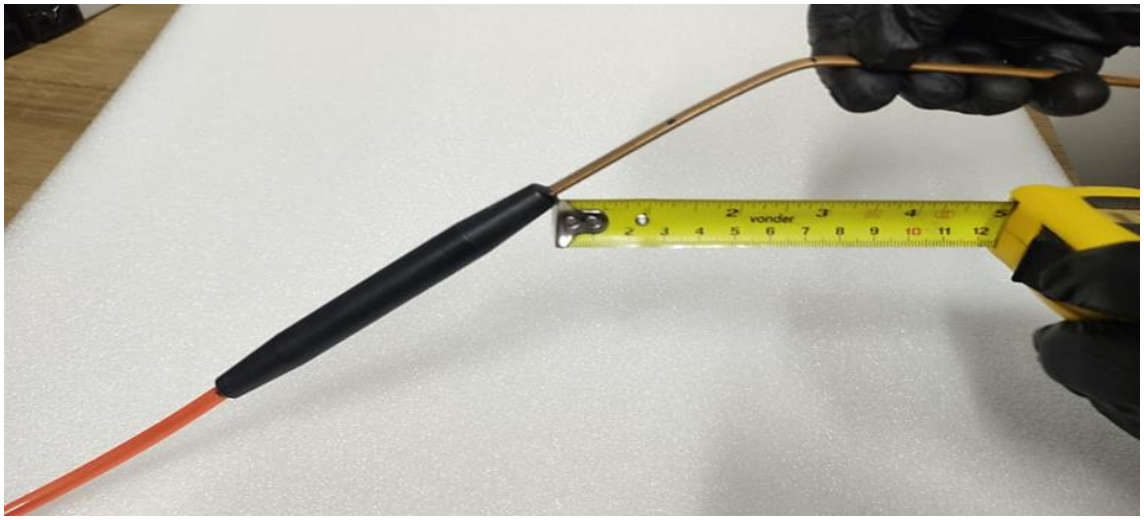


Figure 48

41) Then make the 30° fold at the 40mm mark:

Figure 49

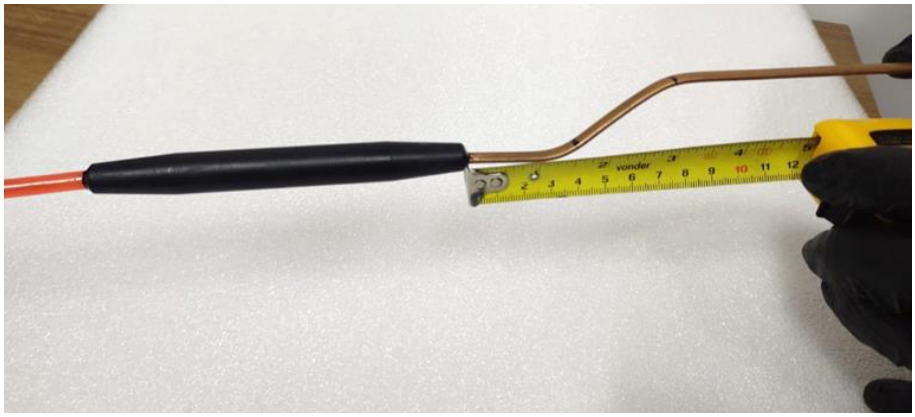


Figure 50

6.2. Bracket Installation

42) In the first and last 200mm of the Sensor, place a bracket every 50mm so that it is no more than 10mm from the bend. In the rest of the Sensor area, place a bracket every 150mm.
43) Make markings on the sensor using a permanent marker.

Figure 51

44) Insert the brackets into the sensor:

Figure 52

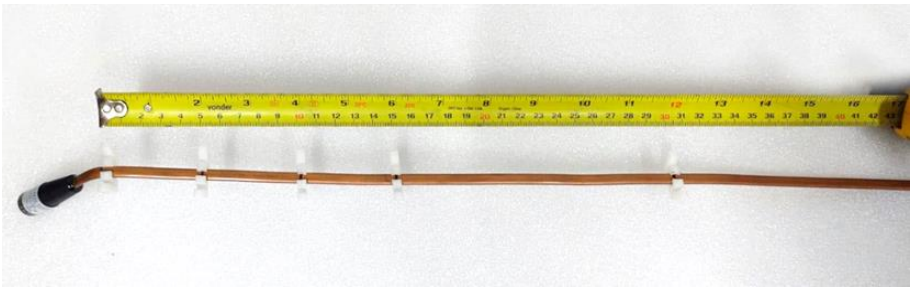


Figure 53

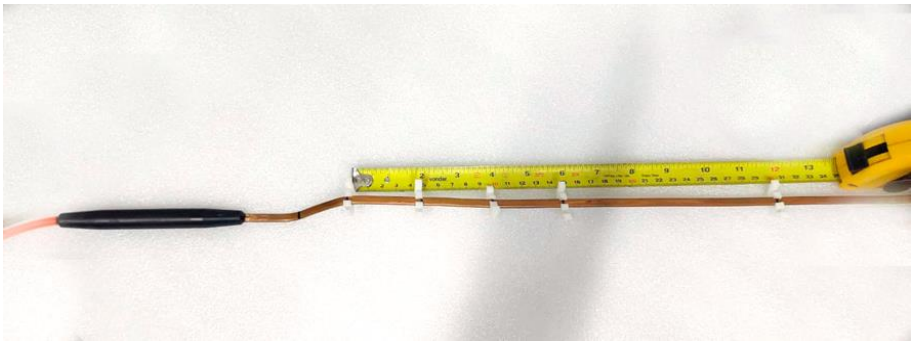


Figure 54

Figure 55

7. Piezo Sensor Installation

To perform this service, you will need the following equipment:

- Application Tool

The Sensor installation must be executed by at least two technicians.

45) Place the Sensor in the cut in the asphalt.

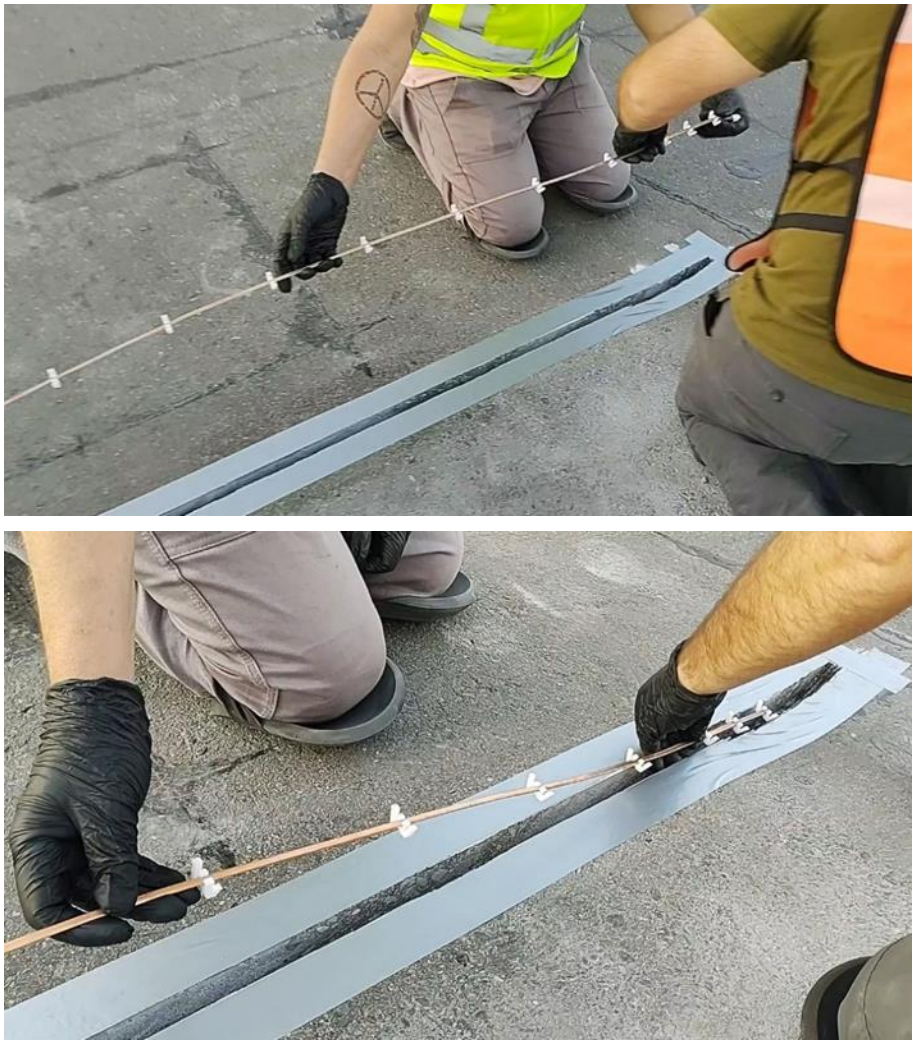


Figure 56

46) To apply the brackets to the cut, proceed starting with the Sensor tip (opposite side to the Cable exit), ensuring correct installation.

Use the Application Tool to press the Brackets into the depth of the cut.
<u>DO NOT</u> use your fingers or any other tool or method to insert the sensor into the cut.

It is essential to exercise care when positioning the Bracket, ensuring that it is installed in a completely vertical and aligned manner.

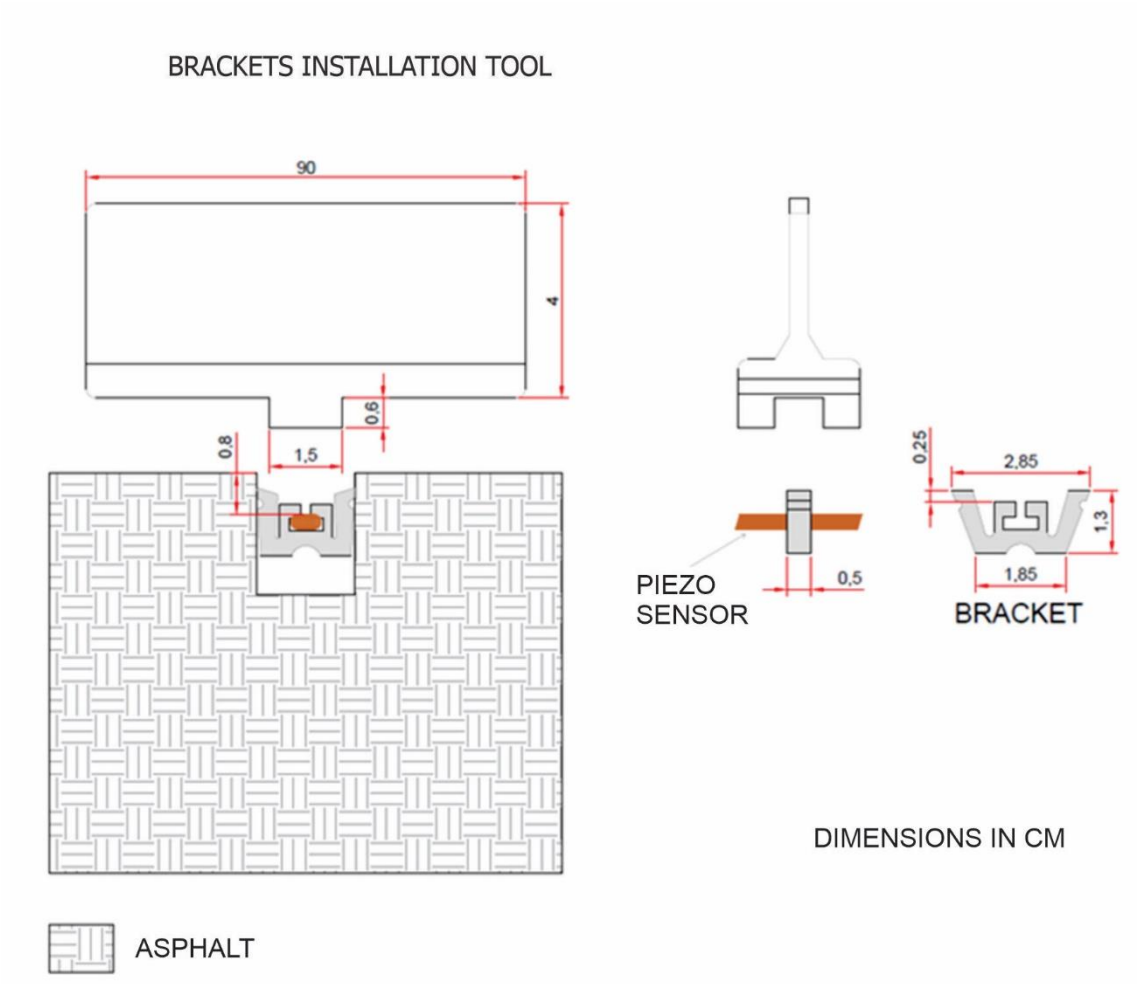


Figure 57

Figure 58

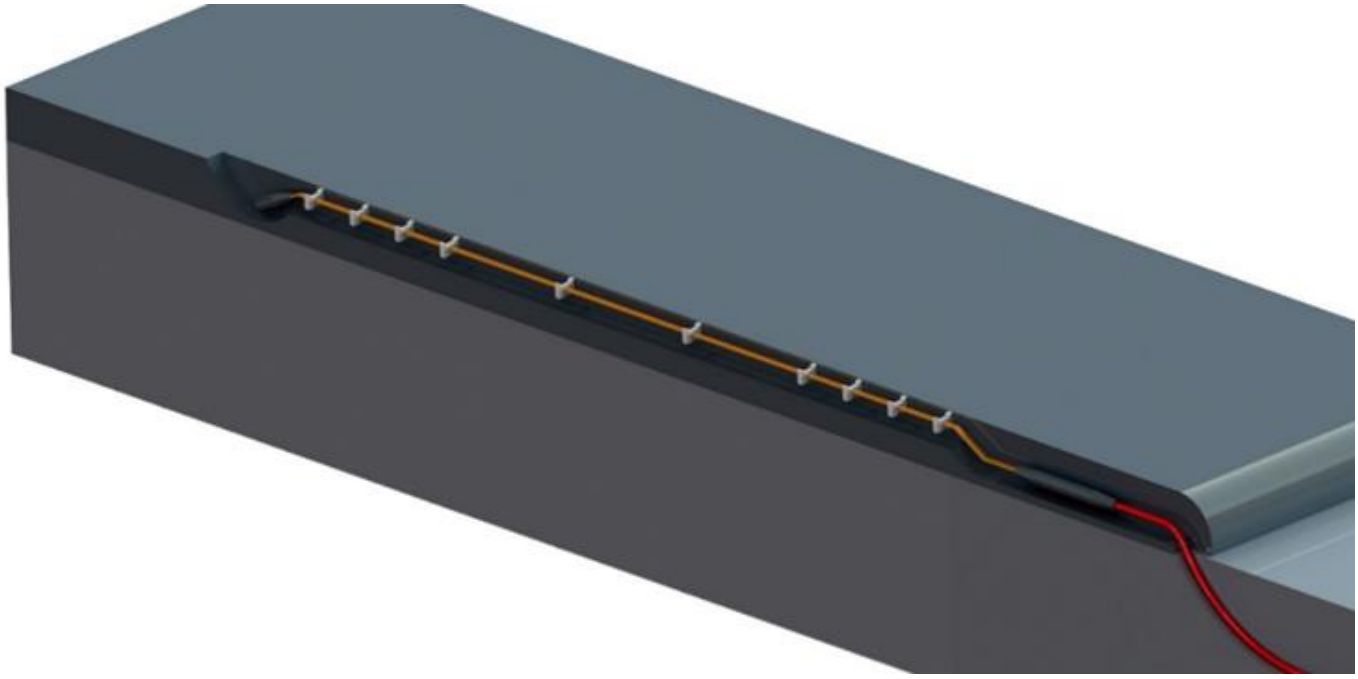


Figure 59

7.1. Piezo Sensor Cable Protection

47) On the Sensor Cable Exit side, insert tow or Styrofoam (you can use the sensor's own packaging) to protect the cable so that the resin does not run towards the cable or out of the cut.

Figure 60

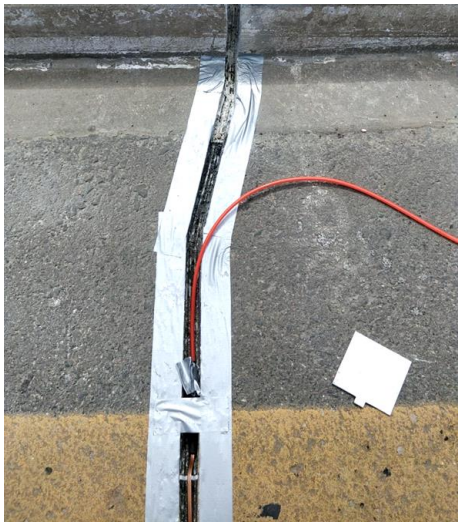


Figure 61

48) Place the Sisal Rope over the Cable to protect it from being covered with Tar at the end of the installation.

Figura 62

Figure 63

Make sure the sisal rope is covering the entire handle, filling the entire cut space. Under no circumstances may the tar come into direct contact with the cables.

7.2. Post-Installation Testing

Perform the test with the Sensor stable. DO NOT perform the test with vehicles over the Sensor. Avoid any type of vibration on the floor during testing.

To perform this service, the following items and equipment will be required:

- Digital Multimeter
- BNC Connector/Terminal CNC00035

7.2.1. Capacitance Test

49) Use the Digital Multimeter to measure the capacitance across the sensor.
50) Measurements must be within the range as per the data sheets that accompany each Sensor.
51) Set the Capacimeter to the 20nF range.
52) Insert the Female BNC connector into the male BNC connector of the sensor cable.
53) Insert the red test lead of the Capacimeter into the "+" of the Female BNC connector and the black test lead into the "-" of the Female BNC connector.

Pay attention to your hands. Make sure they do not touch metal parts when measuring.

Figure 64

7.2.2. Endurance Test

54) Use the Digital Multimeter to measure the resistance across the sensor.
55) Set the Multimeter to the 20MΩ range.
56) The reading table should be greater than 20MΩ (open), usually shows with "1" or "0L" to indicate correct measurement.

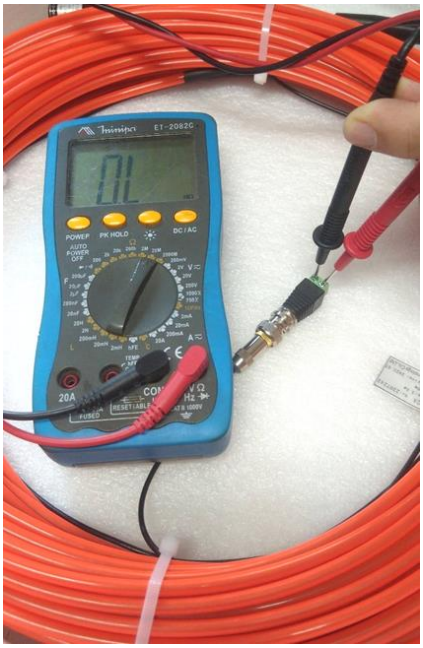


Figure 65

8. Temperature Sensor Placement

57) Insert the Temperature Sensor into the cut:

Figure 66

58) Guide the Sensor Cable through the cut for cable passage, heading towards the terminal box and then to the cabinet.

9. Cable Passage

59) Pass the sensor cables through the passage cuts to the trackside terminal box.
60) Roll the excess sensor cable into a diameter approximately 15% smaller than the width of the terminal box and secure it with electrical tape so that it does not come loose.
61) Insert the rolled part into the terminal box.

Figure 67

62) Pass the cables through the slot to the terminal box near the Post with the Cabinet.

Note: Use the Old Cutting Disc or Screwdriver to make it easier to insert the cable into the slot.

Figure 68

63) Place the Sisal Rope over the Cables to protect them from being covered with Tar at the end of the installation.

Figure 69

Figure 70

Make sure the sisal rope is covering the entire handle, filling the entire cut space. Under no circumstances may the tar come into direct contact with the cables.

10. Closing the cut in the asphalt for the Piezo Sensor

10.1. Resin Cement Preparation

To perform this service, the following items and equipment will be required:

- Catalyst
- Resin
- Power Generator
- Mason's Trowel or Silicone Spatula
- Mass Mixer
- Cordless speed-adjustable screwdriver

The resin CANNOT be exposed to the sun or in very hot environments. Keep the catalyst and resin in a cool, airy place, never exposed to sunlight.
If the resin is too hot when mixed with the catalyst, it may boil, rendering it unusable. In this case, DO NOT apply it to the sensor.

Use a screwdriver or an electric paint mixer on low speed to mix in a cool, airy place, away from sunlight.

64) Mix the resin using the mixing paddle and the drill at slow speed for 2 minutes, mixing all the components well until you have a homogeneous mixture. Check that there is no settled material at the bottom of the can.

Figure 71

65) Add the catalyst (Group AB) little by little to the resin and mix it at slow speed for a maximum of 1 minute, mixing all the components well.

Figure 72

10.2. Application of Resin Cement

Any loose asphalt material should be brushed away before pouring the sealant into the cracks. Be careful not to raise the sensor profile.

Pour the Resin Cement only into the Sensor, it is not necessary to pour it into the cable passage cuts.

Perform this process as soon as possible, before 7 minutes, to prevent the resin from solidifying.
Do not handle the resin if it is thick (sticking).

66) Immediately after mixing, evenly pour the grout (Group AB) into the cut starting from the center of the track (highest part of the pavement) towards the roadside.
67) Pour small amounts along the route, avoiding resin falling onto the side protective strips. If this happens, use the trowel or spatula to direct the resin towards the cut.
68) Repeat until the cut is completely filled with resin cement.
69) Using the spatula, lightly spread the resin cement along the length of the cut. The resin should overflow until it reaches the adhesive tape, but in small quantities, maximum 1 mm above the pavement, proportionally throughout the cut.

Figure 73

Figure 74

Ensure that when applying the resin it is higher than the pavement, but not too much (1 to 2 mm).

70) Remove the adhesive tapes before the resin becomes too thick. If it is not possible, leave the tape.

Remove the tapes at a 45° angle to the cut.

Figure 75

Figure 76

71) If the resin is at a point lower than the pavement, a second application of resin will be necessary in these locations. The second grout should ensure that the colloidal surface is slightly higher than the road surface. The final result should be the same as in the image, depending only on the sanding process:

Figure 77

10.3. Surface Polishing

Necessary Material:

- Power Generator
- Hand Grinder Model GWS 2B-230
- 115mm Diamond Grinding Wheel M14 Thread for Grinder

72) Between 20 and 40 minutes after applying the resin cement (depending on the temperature) and the resin has completely solidified and cured, use the 115mm M14 thread diamond grinding disc with the Grinder and level the surface where the cement resin was applied so that it is at the same level as the pavement along its entire length (do not grind below the level of the track).

Note: Make sure the resin is not above or below the pavement level throughout its entire length.

Note: If it was necessary to leave the adhesive tape, remove it while polishing.

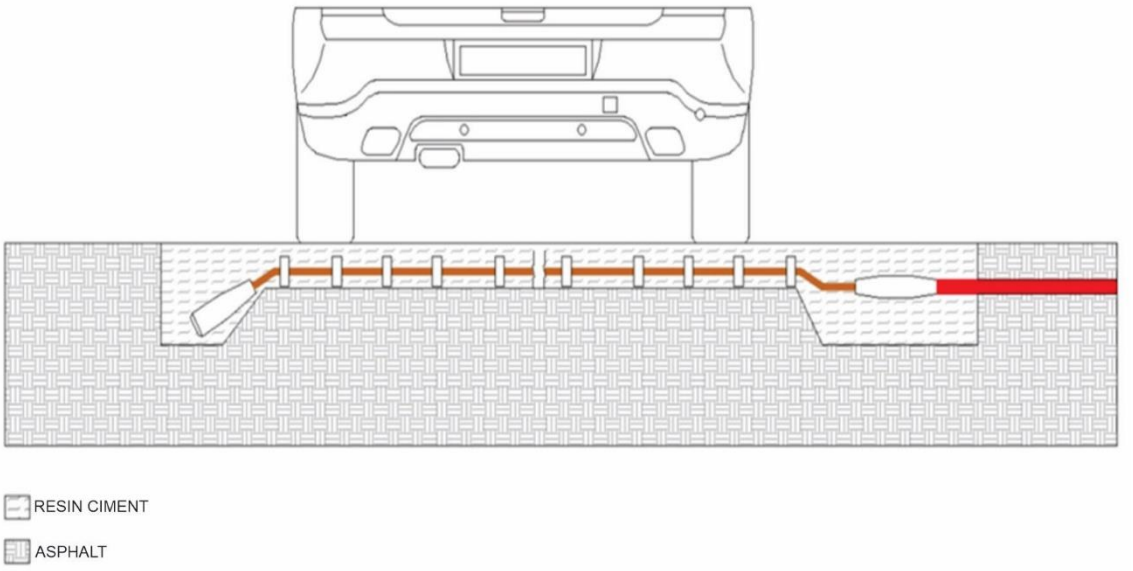


Figure 78

Figure 79

11. Closing the Cable Passage Cut

73) Prepare the gas cylinder with the stove.

Note: Be careful when handling the Stove. Handle it in a place protected from the wind so that there is no risk of the flame going out.

74) Pour the Oxidized Asphalt into the Container and heat it until smoke begins to come out.

Note: Be careful not to heat the tar too much, as it could catch fire.

75) Using the jar, remove the tar from the container and pour it into the cut until it overflows.

Note: The tar should be poured when the pavement is wet or dirty, the pavement should not be cleaned after cutting.

Note: Avoid splashing tar on the floor when transporting it with the jar. To prevent this from happening, use a bowl underneath the jar.

Figure 80

Figure 81

Figure 82

Figure 83

76) After the tar has cooled, use a backhoe to scrape it off the pavement:

Figure 84

77) When finished, gather the tools and clean the area with a broom, leaving no residue or tar residue.

12. Pre-Load Test

To perform this service, you will need the following equipment:

- Digital Oscilloscope

12.1. Test Procedure

78) After the mounting surface is clean, connect the sensor exit terminal to the oscilloscope.
79) The typical oscilloscope setup is:

80) Voltage 200mV/div;
81) Time 400ms / div;
82) For a positive signal, the trigger voltage setting should be 50mV.
83) Collect a typical waveform of a van and a car as a preload test waveform, and then store, copy and print the test waveform for permanent storage.

Example of preload test waveform diagrams:

Figure 85 - Biaxial

Figure 86 - Triaxial

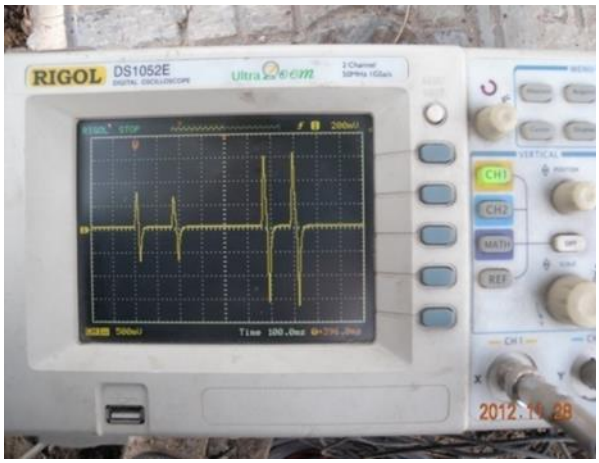


Figure 87 – Four axis

Figure 88 – Six Axis

84) The sensor output depends on the installation method, sensor length, cable length and bottling materials used. If the pre-pressure tests are normal, this installation is complete and the road can be opened to traffic.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