USERS MANUAL

ELECTRICAL FIELD VANE INSTRUMENT

GEOTECH EVT 2000
Figure 1.1: Geotech Electrical Vane Test Instrument, Eurocode model

Figure 1.2: Geotech Electrical Vane Test Apparatus, Standard model
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# DOCUMENT HISTORY

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1. INTRODUCTION

With the Electrical Vane Test Apparatus the undrained and remoulded shear strengths of clays can be measured in situ and the layer sensitivity calculated.

The electrical vane instrument is used for two models for the downhole equipment, a standard one with tapered vanes, no protection for the vanes and extension rods, and a Eurocode model with rectangular vanes, a vane protection and extension tubes. This model follows the Eurocode ENV 1997-3, part 3. It can be rammed through hard layers.

Both models are equipped with an electrical instrument head to be mounted on a site investigation rig or a static penetrometer, and downhole equipment consisting of vanes, a slip-coupling and extension rods. These are the same as the ones used with the Nilcon mechanical vane apparatus.

During a test, the vane instrument rotates the extension rods from the surface. Downhole, the torque is taken up during the first 15 degrees of rotation by the slip-coupling on top of the vane. Thereafter, the torque is transmitted to the vane. The speed of rotation is set manually. The recording of the torque, measured with strain gauges, is done every half degree with the Geotech software Vane-log, installed on your laptop. Please refer to separate manual for information about the software.

When editing the test data, the rod friction is deducted from the maximum applied torque and given the dimensions of the vane used, the undrained shear strength is calculated, displayed and stored by the software. The stored shear strength values are then displayed as a function of depth according to the Swedish Geotechnical Society (SGF) format.

With the standard model, between tests in a sounding, the vane is further pressed into the ground with the extension rods which run through the chuck of the Vane Instrument Head. The Eurocode model comes with a vane protection and extension tubes. After each test, the vane is pulled back up and locked in its protection. The vane protection is then pressed deeper into the ground with the extension tubes.

![Figure 1.3: Shear loading curve from the Vane-log software.](image-url)
2. LIST OF PARTS (Standard and Eurocode Models)

The Electrical Vane Instrument comes in a standard model and a Eurocode model, the later with protection tubes and a vane protection. The list below shows typical set-ups:

<table>
<thead>
<tr>
<th>Description</th>
<th>P.N.</th>
<th>Quantity (per model)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface equipment</strong></td>
<td></td>
<td>Standard</td>
</tr>
<tr>
<td>Electrical Vane Instrument Head</td>
<td>06838</td>
<td>1</td>
</tr>
<tr>
<td>Torque wrench, control instrument</td>
<td>07630</td>
<td>1</td>
</tr>
<tr>
<td>Fastening ring, instrument head to yoke of penetrometer</td>
<td>10753</td>
<td>1</td>
</tr>
<tr>
<td>Slotted washer</td>
<td>05873</td>
<td>1</td>
</tr>
<tr>
<td>Washer with Ø23 mm centre hole</td>
<td>10484</td>
<td>1</td>
</tr>
<tr>
<td>Spring</td>
<td>11936</td>
<td>1</td>
</tr>
<tr>
<td>Cable power 12 Vdc</td>
<td>41540</td>
<td>1</td>
</tr>
<tr>
<td>Cable serial interface-PC</td>
<td>08562</td>
<td>1</td>
</tr>
<tr>
<td>Logging software VANE-Log (CD and HASP key)</td>
<td>13187</td>
<td>1</td>
</tr>
<tr>
<td>Transport case for vane instrument head, cables &amp; accessories</td>
<td>44003</td>
<td>1</td>
</tr>
<tr>
<td><strong>Downhole equipment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vane Ø50 x 110 mm, tapered lower end</td>
<td>00162</td>
<td>1</td>
</tr>
<tr>
<td>Vane Ø65 x 130 mm, tapered lower end</td>
<td>00163</td>
<td>1</td>
</tr>
<tr>
<td>Vane Ø80 x 172 mm, tapered lower end</td>
<td>00164</td>
<td>1</td>
</tr>
<tr>
<td>Slip-coupling for Ø22 mm extension rods (15 degrees clockwise)</td>
<td>00153</td>
<td>1</td>
</tr>
<tr>
<td>Vane equipment Eurocode, comprising: Slip-coupling for Ø22 mm extension rods (15 degrees clockwise), with stop flange, 1 pc</td>
<td>09533</td>
<td>1</td>
</tr>
<tr>
<td>Vane protection, OD 75, L 820 mm, 1 pc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vane Ø65 x 130 mm, rectangular ends (09534), 1pc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extension rods, Ø22 x 1 000 mm, with conn. pieces</td>
<td>00884</td>
<td>40</td>
</tr>
<tr>
<td>Extension tubes (SPT) Ø42 x 1 000 mm, with conn. pieces</td>
<td>01393</td>
<td>40</td>
</tr>
<tr>
<td>Transport case for extension rods and tubes</td>
<td>09485</td>
<td>1</td>
</tr>
</tbody>
</table>

Special vanes and vanes according to different national standards are available on request.
3. TECHNICAL SPECIFICATIONS - Vane Instrument Head

The Electrical Vane Instrument Head is the same for the two available models, the Standard and Eurocode model.

**Electrical Vane Instrument Head Specifications**

- **Measuring range:** 100 Nm (130 Nm)
- **Measuring accuracy:** <1% F.S.
- **Speed:** Adjustable 0 – 1.5 deg/s
- **Dimensions (L x w x h):** 360 x 210 x 110 mm, excluding chuck of 140 mm height (see figure on cover)
- **Chuck location:** Excentered along length axis (see cover figure), 125 & 85 mm from each side
- **Chuck size:** Ø22 - 25 mm, Manual
- **Spindle hole:** 25 mm
- **Weight:** 16 kg
- **Power supply:** 12 – 15 V DC, 36W
- **Computer communication:** RS 232C
- **Communication with PC:** Cable Geotech
- **Ambient temperature:** -20 to +40 °C

The Electrical Vane Instrument Head is delivered in a practical transportation case, in which also cables and other accessories can be stored.

![Vane Instrument Control Panel](image)

**Figure 3.1: – Vane Instrument Controls**

<table>
<thead>
<tr>
<th>Vane Instrument Control Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Switch for direction</td>
</tr>
<tr>
<td>2. Rotation speed</td>
</tr>
<tr>
<td>3. Computer connection RS232</td>
</tr>
<tr>
<td>4. Power connection 12V DC</td>
</tr>
<tr>
<td>5. Fuse</td>
</tr>
</tbody>
</table>
4. MOUNTING OF VANE INSTRUMENT HEAD

The Electrical Vane Instrument Head should be rigidly mounted on the yoke of your site investigation rig or static penetrometer, or the case may be on the top hole casing. We strongly recommend you to use the fastening ring (P.N. 10753).

The panel of the instrument should be conveniently accessible as the vane rotation speed is adjusted from there.

NOTE: THE CHUCK OF THE VANE INSTRUMENT HEAD MUST NEVER BE USED FOR PRESSING RODS DOWN OR PULLING THEM UP. NEITHER MAY ANY PART OF THE INSTRUMENT BE USED FOR PRESSING DOWN EXTENSION TUBES.

Figure 4.1: Use the fastening ring (P.N. 10753) for mounting the instrument head to the yoke of your investigation rig or penetrometer.
For use with a Geotech site investigation rig, please refer to the rig’s manual for mounting details.

When using a rig or a static penetrometer not from Geotech, make certain that the separation between the inner cylinders of the static penetrometer is more than 250 mm. The Vane Instrument Head can then be fit on top of the pushing yoke. If the separation between the inner cylinders is less than 250 mm, the Vane Instrument Head might be mounted underneath the pushing yoke.

Use the fastening ring to assemble the vane instrument head firmly on your rig/penetrometer. (See fig. 4.1).

**For use with standard model vane**
The standard model vane equipment does not have any vane or rod protection. Depending on rig model, the vane instrument head can normally be left on the machine while pushing down and pulling up rods. Note: The chuck of the instrument may never be engaged while pushing or pulling up rods.

**For use with Eurocode vane equipment**
In the Eurocode model, the down-hole equipment consisting of a vane and its protection, is pressed into the ground with extension tubes, in which the extension rods run.

As for the Standard model, the Vane Instrument Head should be mounted firmly during tests on a site investigation rig, on top of a chuck gripping the extension tubes or on a static penetrometer on top or underneath the pushing yoke.

Unlike the Standard model, it is strongly recommended that the Vane Instrument Head is only mounted when testing and removed when pressing or pulling extension tubes and rods. This is to
avoid the risk of damaging the instrument by hitting it against the top extension tube when the chuck or yoke is pushed downwards.

Provided the vane is properly introduced in its protection, it can be rammed through hard layers.

5. USE OF VANE INSTRUMENT HEAD

a. Connecting Vane Instrument Head to a PC and power supply.
The Geotech logging software VANE-Log has to be installed on your computer prior to the test.

On a Geotech site investigation rig
When using a Geotech rig you normally only need one cable for the vane instrument. Connect the cable to the serial port on the vane instrument head and to the connecting box on your rig. The cable allows for both data communication from the Vane Instrument Head to the PC and power supply to the Vane Instrument Head.

On other rig or penetrometer
Connect the power supply cable to the power contact on the rig or other source and to the power contact on the vane instrument panel. The voltage should be 12-15V dc.
Connect the serial cable to the serial port on the vane instrument head and directly to your PC.

b. Rotation speed adjustment
The rotation speed or time to failure varies in the national vane test standards. The Eurocode says that the vane has to rotate at a constant speed between 0.1 and 0.2 degree per second (6-12 degrees per minute). The speed can therefore be adjusted with a rotation speed regulator or potentiometer on the panel of the Vane Instrument Head (See fig. 3.1) and can be monitored on the screen display of the VANE-Log software.

The zero position of the speed control is at full stop, anti-clockwise direction. The speed of rotation increases, when turning the potentiometer clockwise,

Since the torsion in the rod string increases with increasing depth, the position of the potentiometer has to be shifted further clockwise, the deeper the test is carried out in order to maintain a constant speed of rotation.

c. Switch for direction
If the switch (See fig. 3.1) is in position 0, the instrument’s chuck is still, independently of the position of the rotation speed control. In position 2, the chuck rotates in the clockwise direction (direction always used during tests), at the speed given by the rotation speed control.

When the test is completed, the extension rod must be loosened from the chuck. At very high torques, this can be hard to achieve. If so, put the switch in position 1. The rod will rotate anti-clockwise until the chuck can be loosened.

d. Chuck of Vane Instrument Head
The manual chuck of the instrument head is fastened in an open position, by turning manually the chuck ring leftwards to a stop and pressing downwards.

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The chuck is loosened from the fastened position, by lifting the ring and letting it go. With the spring in the chuck, the rod is gripped automatically.

**ALWAYS OPEN THE MANUAL CHUCK OF THE INSTRUMENT HEAD BEFORE PUSHING DOWN RODS OR PULLING THEM UP.**

**ALWAYS LOCK THE RODS WITH THE HYDRAULIC CHUCK ON THE DRILL HEAD OF THE SITE INVESTIGATION RIG OR ON THE YOKE OF THE STATIC PENETROMETER BEFORE PUSHING DOWN OR PULLING UP RODS.**

### 6. EQUIPMENT MAINTENANCE

The Vane Instrument Head has to be regularly calibrated. Keep it clean at all times, and do not allow any contamination of the chuck. Store the equipment in controlled environment (warm and dry) when not in use.

The downhole equipment should be kept clean and dry, in particular keep the scraper and the Seeger-ring clean. These avoid the penetration of soil in the vane housing.

In the Eurocode model, the downhole equipment with the vane protection should be cleaned and greased after use.

![Vane equipment Eurocode](image)

*Figure 6.1 Vane equipment Eurocode.*
7. MOUNTING OF DOWNHOLE EQUIPMENT AND TEST PREPARATION

a. Standard Model

The chosen vane with lower tapered ends is connected to a slip-coupling and then to Ø22 mm extension rods.

Test Preparations:

1) First, connect the vane to the slip coupling and tighten firmly.

2) Connect the extension rods to the slip coupling and tighten firmly. Any loose connection will change the rotation angle/torque relationship in the first vane test.

3) Pre-drill through the dry crust, or fill, with a diameter exceeding the vane size.

4) Put the vane in the pre drilled hole.

5) Lower the drill head of the site investigation rig or yoke of your static penetrometer on to the top of the extension rod. Check that the slip of the slip coupling is forced to its anti-clockwise end position.

6) Grip the extension rod and subsequent rods with the hydraulic chuck of your site investigation rig and press the vane down to the first test level.

7) When the first test level is reached, open the hydraulic chuck completely and keep it open during the test.

8) Check carefully that the rod rotates freely.

9) Lock the manual chuck on the instrument by lifting the chuck ring and letting it go. The spring in the chuck will lock the instrument over the rod.

10) After completion of the test, unlock the manual chuck, lock the hydraulic chuck of the site investigation rig and proceed pressing the vane down to the next level to be tested.

**THE MANUAL CHUCK OF THE INSTRUMENT MUST BE LOCKED IN ITS OPEN POSITION DURING ALL PRESSING DOWN OR PULLING UP OPERATIONS**
b. Eurocode Model
The vanes of the Eurocode model, with rectangular ends, are slid into a steel protection when pressed into the ground (Figure 6.1 and 7.2). The vane protection consists of:

- Housing for vane with four slits at right angles
- Gliding brass surface to reduce friction between slip-coupling and housing during tests.
- Housing for slip-coupling with spring lock
- Connection to extension tubes Ø42 mm

Test Preparations:

1) Assemble the chosen vane, slip coupling with end stops, extension rod and vane protection tube and tighten all vane connections firmly. Any loose connection will change the rotation angle/torque relationship in the first vane test. Connect the vane protection to a first extension tube.

2) Pre-drill through the dry crust, or fill, with a diameter exceeding the vane protection and put the vane protection in the pre drilled hole.

3) Lower the drill head of the site investigation rig or yoke of your static penetrometer on to the top of the extension tube. Be careful when extending the inner rods, in tightening the connections. Poor tightening will show as a flattening of the test curves.

4) Grip and push the extension tube and subsequent tubes with the hydraulic chuck of your site investigation rig or press them with the pushing yoke of your static penetrometer until the vane protection is 36 cm above the first level to test.

5) Mount the Vane Instrument Head firmly in its test position, with the top extension rod going through the manual chuck of the instrument.

6) Hammer gently with a soft hammer (not to damage the rod) on the inner rod to loosen the slip-coupling from its spring lock and lower the vane 36 cm. The stop flange of the slip-coupling meets a gliding brass surface which will take the weight of the inner rods. Check carefully that the rod rotates freely. Lock the manual chuck on the instrument by lifting the chuck ring and letting it go.

7) After completion of the test, unlock the manual chuck and remove the Vane Instrument Head. Place a steel plate (washer) with an Ø23 mm centre hole on the yoke. Put the spring on top of the plate with extension rod through it and lock with the appropriate rod lock (slotted washer). Carefully pull the lower steel plate up some 220 mm with respect to the top of the extension tube until the spring contracts. The upper end of the vane is now in contact with the lower end of the vane protection. See fig. 7.3.

9) Stop pulling up and slowly rotate the extension rod until the spring is relaxed (the spring is fully contracted with a 150 kg load). The blades of the vane will now have entered into the slits in the vane protection. Pull up the rod 140 mm so that the slip-coupling is firmly locked in spring lock of the vane protection. Never pull with more than a few hundred kilograms in order to avoid damages on the pins of the slip-coupling.
Figure 7.2: Vane Protection in cross-section, upper part, left, with slip-coupling in its spring lock. Lower part, right, with vane in its protection. Moving parts in grey.

10) Remove the spring, Rod Lock and steel plate and proceed to the next level to test.
11) In case the vane is rammed, tighten the rods by rotating the last rod clockwise every meter. The connections may otherwise get loose and the ramming lead to undue wearing of the connection threads.

Fig. 7.3: Setup for retracting the vane into the vane protection. Note that specially designed equipment might occur, depending on rig or penetrator model.

8. VANE TEST

a. Undrained Shear Test
The vane test is carried out by rotating the extension rod and vane with the speed specified in the applicable national standard. According to Eurocode, the vane should rotate at a constant speed between 0.1 and 0.2 degrees per second (6-12 degrees per minute). For adjusting the speed of rotation, see “Use of Vane Instrument Head” above.

Follow the screen display to see that the rod friction is recorded in the first 15 degrees of torsion and is followed by a shear loading on the vane. The shape of the curve varies with the type of soil. Upon failure, the curve drops.

b. Test under Remoulded Conditions
When a test is carried out under remoulded conditions, the vane is turned rapidly at least ten turns according to the Eurocode. This may be done by rotating the vane with the rotation speed control at full speed.

9. CALIBRATION OF THE VANE INSTRUMENT HEAD

The objective of the calibration of the Electric Vane Instrument Head is to verify any drift of the torque reading of the instrument by applying known torques.

The instrument is fixed in a holding device with a jaw vice, with the extension rod axis horizontal.

Weld a rod, over one meter long with a balance pan hanging at one end, on an extension rod to act as a balance arm. The rod should be welded at its centre of gravity with the balance pan hanging, so that the free end of the rod counterweights the balance pan.

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Introduce the extension rod in the Vane Instrument Head and verify that the balance arm is balanced, with no weights in the pan. Lock the chuck and place a one kilogram weight in the pan. Run the instrument until the arm is horizontal and read the torque.

Repeat the procedure with additional one-kilogram weights up to 10 kilograms and plot the readout values as a function of the applied torque.

Remove the extension rod and introduce from the other end and lock the chuck. Repeat the entire procedure, including a plot.

Look for a calibration factor that minimizes the difference between applied torque and readout over the entire range. The new calibration or scaling factor should be close to 1 Nm/Nm and is then fed in the VANE software, under Cal-codes, before all vane tests.

The calibration should be repeated at least once a year or when the instrument has been damaged, overloaded or repaired according to the Swedish standard. Calibration is not specified in the Eurocode.
CALIBRATION CERTIFICATE FOR ELECTRICAL VANE INSTRUMENT

Electrical vane instrument number: EVB-0025
Date of calibration: 2001-09-18
Operator: Mats Tingström

Calibration code: 1.05

Output torque/Measured torque (Nm/Nm). The best fit values in the table underneath are recorded with this code.

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<thead>
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<th>Applied Torque (kpm)</th>
<th>CLOCKWISE LOADING (Nm)</th>
<th>Anticlockwise loading (Nm)</th>
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<tr>
<td>10.19</td>
<td>10</td>
<td>10.26</td>
</tr>
<tr>
<td>20.38</td>
<td>20.01</td>
<td>20.41</td>
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<td>30.57</td>
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<td>50.06</td>
<td>50.41</td>
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<td>81.52</td>
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</tr>
<tr>
<td>101.90</td>
<td>99.55</td>
<td>99.55</td>
</tr>
<tr>
<td>Σ = 550 TOTAL/550=0.998 TOTAL/550=1.004</td>
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</tr>
</tbody>
</table>

* with 1 Nm = 1.019 kpm

Parameters in the *.vib vane test acquisition files:
Angle resolution (AA parameter): 0.5 degree
Time resolution (AD parameter): 1 second
Torque resolution (AB parameter): 0.03 Nm (12 bit resolution over a 100 Nm range)
Torque range: 100 Nm

The measured torque is converted into a shearing force, as follows:
Shear force (kPa) = Applied torque (Nm) x Vane constant (kPa/Nm)

Vanes with tapered lower end:
Vane number: 1 = 110 x 50 mm; Vane constant = 2.0 kPa/Nm; Shearing range = 0-200 kPa
Vane number: 1 = 130 x 65 mm; Vane constant = 1.0 kPa/Nm; Shearing range = 0-100 kPa
Vane number: 1 = 172 x 80 mm; Vane constant = 0.5 kPa/Nm; Shearing range = 0-50 kPa

Vanes with rectangular cross-section:
Vane number: 1 = 100 x 50 mm; Vane constant = 2.2 kPa/Nm; Shearing range = 0-220 kPa
Vane number: 1 = 130 x 65 mm; Vane constant = 1.0 kPa/Nm; Shearing range = 0-100 kPa
APPENDIX 1: CALCULATION OF VANE CONSTANT

Note: The latest versions of the Vane-Log software will automatically apply the vane constant corresponding to the selected vane properties.

The vane constant $C$ is calculated as follows:

$$\tau = T \times C$$

Where:

- $\tau$ = shear strength of the clay (kPa)
- $T$ = measured torque at shearing failure (Nm)
- $C$ = vane constant (kPa/Nm)

The shear strength on the surfaces of the vane is as follows:

- Top surface: $T = \frac{\tau \cdot \pi \cdot D^3}{12}$
- Cylindrical surface: $T = \frac{\tau \cdot \pi \cdot D^2 \cdot H}{2}$
- Tapered end (120\(^\circ\) apex): $T = \frac{\tau \cdot \pi \cdot D^3}{4 \cdot \sqrt{6}}$

Where:

- $D$ = measured diameter of the vane
- $H$ = measured height of the vane

In the above figure, the shearing along the extension rod prolonging the vane has been neglected.

1. For vanes with tapered lower end (120\(^\circ\) apex):

   $$T = \frac{\tau \cdot \pi \cdot D^3}{12} + \frac{\tau \cdot \pi \cdot D^2 \cdot H}{2} + \frac{\tau \cdot \pi \cdot D^3}{4 \cdot \sqrt{6}}$$

   $$T = \frac{\tau \cdot \pi \cdot D^3}{2} \left( \frac{D}{6} + \frac{D}{2 \cdot \sqrt{6}} + H \right)$$

   Set $C = \frac{\tau}{T}$:

   $$C = \frac{2}{\pi \cdot D^2} \cdot \frac{1}{\left( \frac{D}{6} + \frac{D}{2 \cdot \sqrt{6}} + H \right)}$$
The approximate vane constant for some common tapered vanes:

<table>
<thead>
<tr>
<th>Number</th>
<th>Size (cm)</th>
<th>Constant (kPa/Nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11.0 x 5.0</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>13.0 x 6.5</td>
<td>1.0</td>
</tr>
<tr>
<td>3</td>
<td>17.2 x 8.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

2. For vanes with rectangular ends, the constant $C$ is equal to

$$
C = \frac{2}{\pi \cdot D^2} \cdot \frac{1}{\left(\frac{D}{3} + H\right)}
$$

With a height to diameter relation of 2:1, the equation simplifies into approx.: 

$$
C = \frac{273 \cdot 10^{-3}}{D^3}
$$

The approximate vane constant for some common rectangular vanes:

<table>
<thead>
<tr>
<th>Number</th>
<th>Size (cm)</th>
<th>Constant (kPa/Nm)</th>
</tr>
</thead>
<tbody>
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<td>10</td>
<td>10.0 x 5.0</td>
<td>2.2</td>
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<tr>
<td>11</td>
<td>13.0 x 6.5</td>
<td>1.0</td>
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</tbody>
</table>
APPENDIX 2: EXPLODED VIEW OF THE EUROCODE PARTS OF THE VANE APPARATUS
APPENDIX 3: FASTENING RING DRAWING

PN 10753, Fastening ring for mounting the instrument head on the penetrometer yoke.