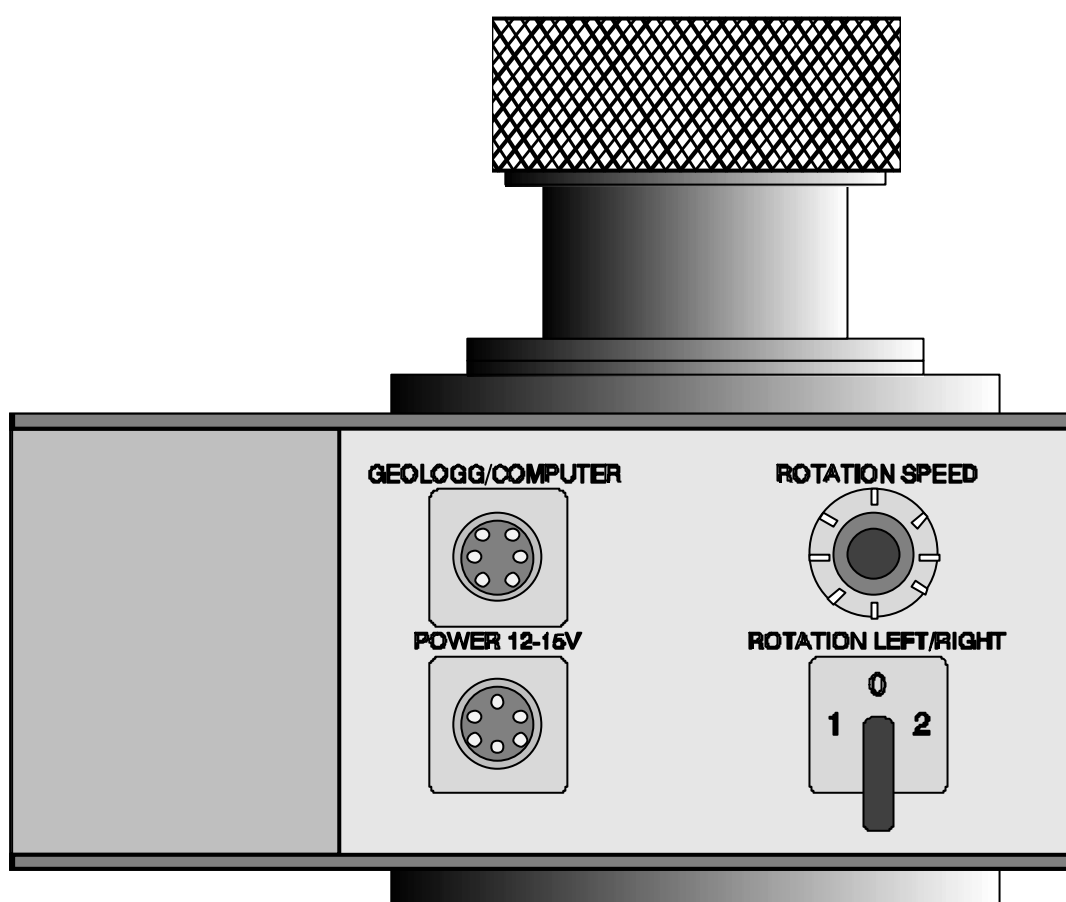


## USERS MANUAL

### ELECTRICAL FIELD VANE APPARATUS

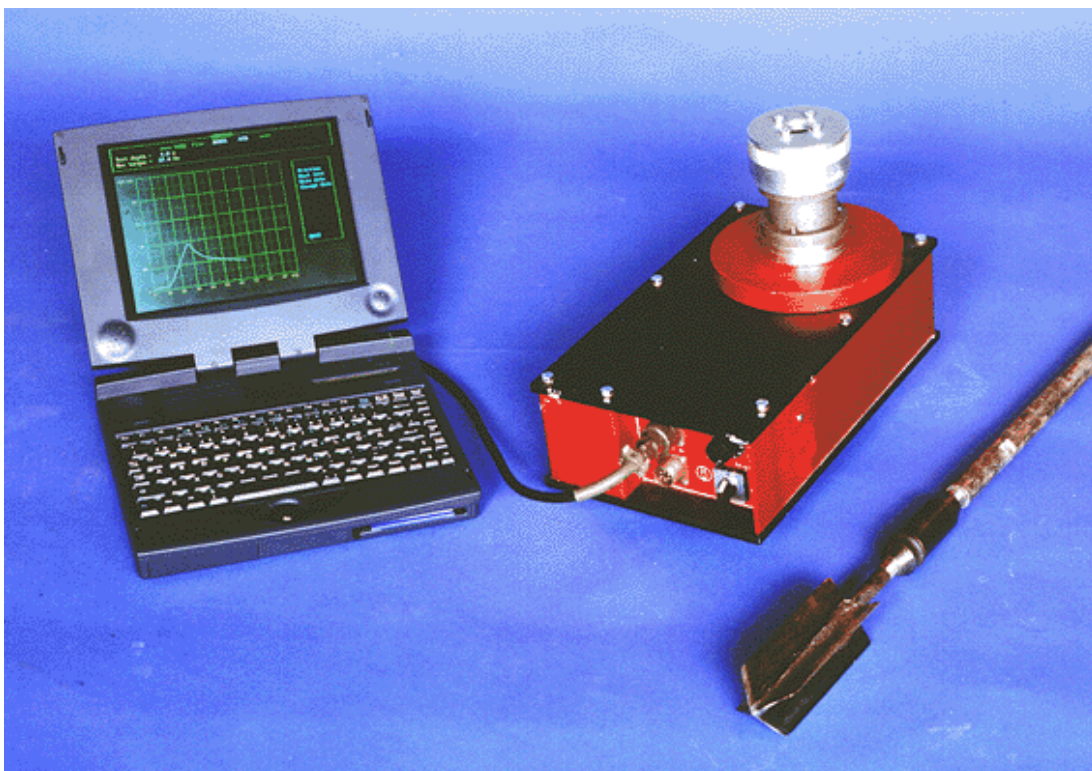
#### PART I: DESCRIPTION OF APPARATUS

# GEOTECH EVT 2000



*Front Panel of Instrument Head of the Electrical Vane Test Apparatus EVT 2000*

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*Figure 1.1: Geotech Electrical Vane Test Apparatus, Eurocode model with (from back to front): Instrument Head, Vane Protection, Extension Tube, Extension Rod, Cable, vane Instrument Head to Computer, Vane with rectangular ends, Slip-coupling and IBM compatible PC-computer (not included)*



*Figure 1.2: Geotech Electrical Vane Test Apparatus, Standard model with (from right to left): Vane with tapered lower end, slip-coupling and extension rod, Instrument Head, IBM compatible PC-computer (not included)*

We thank you for choosing the Geotech Electrical Field Vane Apparatus, EVT 2000 as your vane test instrument. This apparatus is one of the most modern and reliable systems on the market today for measuring shear strengths in clay.

The present manual is a description of the electric vane apparatus. The reader is asked to refer to the software manual for logging (VANE) and editing software (GEOVING) for PC computers.

If you want that the apparatus to function properly for many years to come, please study this manual carefully before taking the equipment into use.

The accuracy of the measurements can only be guaranteed if the apparatus is handled properly, including regular calibrations of the instrument head.

This users manual contains all important data, which are necessary to know, to be able to handle and use the **EVT 2000**.

The one year warranty is valid only if all users and service instructions are followed.

If you have any questions regarding your instrument **EVT 2000**, which are not answered in this manual, please contact Geotech at:

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*Logging of the measurements made in the EVT 2000 instrument head are done in real time either with the Geotech field computers/dataloggers Geologg-PC and Geologg or with a portable IBM compatible computer.*

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## 1. INTRODUCTION

With the Electrical Vane Test Apparatus **EVT 2000** the undrained and remoulded shear strengths of clays can be measured in situ and the layer sensitivity calculated.

FOR ALL VANE TESTS, THE SHEAR LOADING IS RECORDED WITH THE MEASURED TORQUE AS FUNCTION OF THE APPLIED ROTATION ANGLE. THIS IS A UNIQUE QUALITY CONTROL OF THE TESTS THEMSELVES AND ASSURES AND REDUCES TO A MINIMUM THE RISK OF COMMUNICATION ERRORS BETWEEN THE TEST IN THE FIELD AND THE OFFICE.

This **EVT 2000** apparatus comes in two models for the downhole equipment, a standard one (Figure 1.2) with tapered vanes, no protection for the vanes and extension rods, and a Eurocode model (Figure 1.1) 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 **EVT 2000** 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**, installed either in an IBM compatible computer or in a Geotech field computer/datalogger Geologg or Geologg-PC.

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.

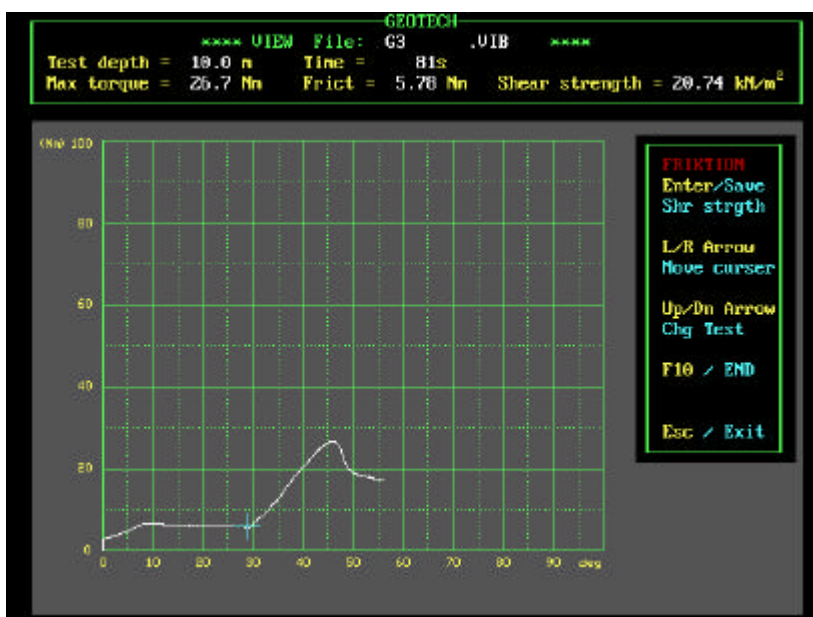


Figure 1.3: Typical shear loading curve with an initial rod friction, followed by shear loading in the tested clay layer. Shear failure is recorded with a torque of 44 Nm. When deducted from the rod friction of 8 Nm this corresponds to a shear strength of 41,64 kN/m<sup>2</sup> with given the shear vane dimensions.



## 2. LIST OF PARTS (Standard and Eurocode Models)

The EVT 2000 Field Vane Apparatus comes in a standard model and a Eurocode model, the later with protection tubes and a vane protection:

Description	P.N.	Quantity (per model)	
		Standard	Eurocode
<i>Surface equipment</i>			
Vane Instrument head	06838	1	1
Torque wrench, control instrument	07630	1	1
Fastening ring, instrument head to yoke of penetrometer	00921	1	1
Spring and Rod Lock			1
Steel plate with Ø23 mm centre hole (not incl.)			1
Cable power 12 Vdc	08533	1	1
Cable serial interface-PC	08562	1	1
Logging software VANE-GL	08559	1	1
Editing software GEOVING	49005	1	1
Transport case: vane instrument head, cables & accessories	44003	1	1
<i>Downhole equipment</i>			
Vane Ø50 x 110 mm, tapered lower end	00162	1	
Vane Ø65 x 130 mm, tapered lower end	00163	1	
Vane Ø65 x 130 mm massive hard. steel, tapered lower end	00010	1	
Vane Ø80 x 172 mm, tapered lower end	00164	1	
Vane Ø65 x 130 mm, rectangular ends			1
Vane, rectangular ends, dim. upon clients' request			(1)
Slip-coupling for Ø22 mm extension rods (15 degrees clockwise)	00153	1	
Slip-coupling for Ø22 mm extension rods (15 degrees clockwise), with stop flange			1
Vane protection, OD 75, L 820 mm			1
Extension rods, Ø22 x 1 000 mm, with conn. pieces	00884	30	30
Extension tubes (SPT) Ø42 x 1 000 mm, with conn. pieces	01393		30
Transport case for extension rods and tubes	08792	1	2

## 3. TECHNICAL SPECIFICATIONS - Vane Instrument head

The **EVT 2000** Vane Instrument Head (P.N. 06838) is the same for the two available models, the Standard and the models.

### Vane Instrument Head EVT 2000

Measuring range:

Measuring accuracy:

### Specifications

100 Nm (130 Nm)

<1% F.S.

Dimensions (L x w x h):	450 x 210 x 110 mm, excluding chuck of 140 mm height (see figure on cover) (210x260x350)
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:	12 Vdc
Computer communication:	RS 232C (with IBM compatible computers)
Communication with Geotech datalogger/field computers Geologg & Geologg-PC	Cable Geotech, P.N. 07885

The **EVT 2000** Vane Instrument Head is delivered in a practical transportation case, in which also cables and other accessories can be stored.

#### 4. MOUNTING OF VANE INSTRUMENT HEAD

With both models, the Vane Instrument Head (P.N. 06838) should be rigidly mounted on the drill head of a site investigation rig, such as the Geotech rigs 504D, 604D, 605D or 705D, on the yoke of a static penetrometer, or, the case may be on the top hole casing.

In all cases of mounting, the panel of the instrument (cover figure) should be readily accessible as the vane rotation speed is adjusted from there.

**IN ALL CASES OF MOUNTING, THE CHUCK OF THE VANE INSTRUMENT HEAD IS NEVER USED TO EITHER GRIP EXTENSION RODS FOR PRESSING THEM DOWN OR PULLING THEM UP, OR FOR PRESSING EXTENSION TUBES DOWN WITH THE TOP SURFACE OF THE CHUCK**

##### *a. Standard Model*

When mounting the Vane Instrument Head on a Geotech site investigation rig, the equipment used is the same as those for the Geotech hydraulic percussion hammer and for the Geotech automatic ram sounding apparatus (Figure 1.4).

The mounting holder is a modified CPT microphone holder with 2 distances welded on top with M8 threads. On the 2 distances, a fastening ring (P.N. 00921) is attached and locked to the instrument head, the same ring as with the mechanical Nilcon instrument.

- Step 1: Mount the hydraulic chuck. Use 2 bolts M16 x 30.
- Step 2: Mount the holder on the drill head or on the hammer legs. Use 2 bolts M16 x 35
- Step 3: Mount the fastening ring on the holder distances. Use 2 bolts M8 x 16.
- Step 4: Place the instrument in the fastening ring and tighten the ring with the tightening screw.

Step 5: Connect the instrument head to an IBM compatible computer with the appropriate cable or to the Geotech field computer/datalogger Geologg-PC.

When using a static penetrometer, 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 and attached using a fastening ring (P.N. 00921).

If the separation between the inner cylinders is less than 250 mm, the Vane Instrument Head can be mounted underneath the pushing yoke.

When the Vane Instrument Head is to be mounted on a top hole casing, please contact Geotech for assistance.

#### *b. Eurocode Model*

In the Eurocode model, the downhole equipment consisting of a vane and its protection, is pressed into the ground with extension tubes (P.N. 01393), in which the extension rods (P.N. 00884) run.

As for the Standard model, the Vane Instrument Head is 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.

**EVT 2000 is now mounted and ready for use.**



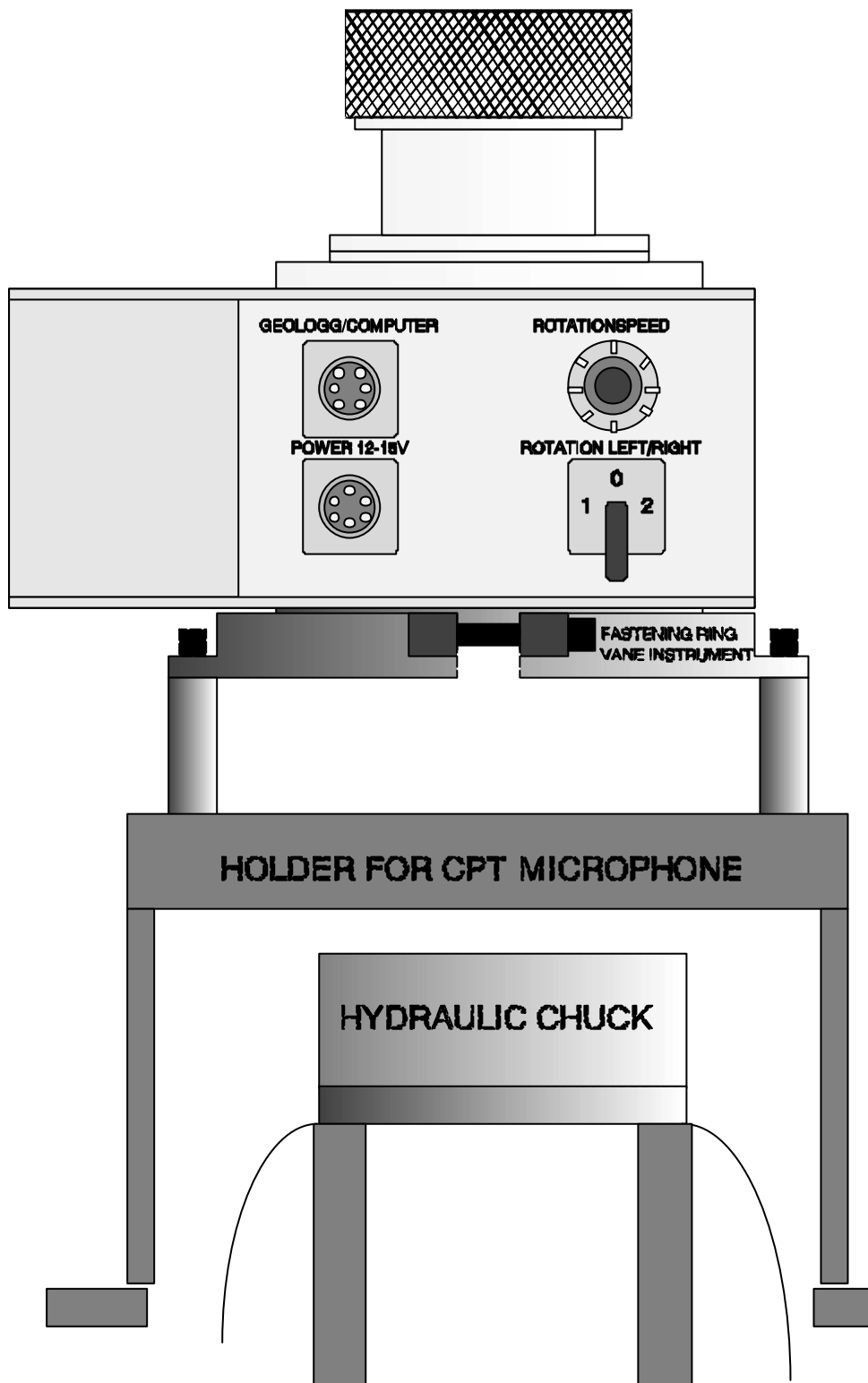


Figure 1.4: Mounting of EVT 2000 on Geotech Site Investigation Rigs

## 5. USE OF VANE INSTRUMENT HEAD

### *a. Connecting Vane Instrument Head to Datalogger*

If the Geotech field computer/datalogger Geologg or Geologg-PC is used to log the vane test, the Geotech logging software VANE-GL (P.N. 08559) must be installed prior to the test.

Connect the cable to the Geologg or Geologg-PC port on the EVT **2000** and the vane port on the Geologg instrument (cover figure). The cable allows for both data communication from the Vane Instrument Head and power supply to the Vane Instrument Head from the Geotech field computer datalogger.

If an IBM compatible computer is used to log the vane test, the Geotech logging software VANE-GL (P.N. 08559) has to be installed prior to the test.

Connect the cable to the contact on **EVT 2000** instrument panel and to the COM 1 or COM 2 port on the computer (cover figure). This cable only allows for data communication.

Connect the power supply cable to the power contact on the rig or other source and to the power contact on the **EVT 2000** instrument panel. The power is 12-15V dc.

### *b. Regulation of Rotation Speed*

The rotation speed or time to failure varies in the national vane test standards. The Eurocode 7 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 (cover figure) and can be monitored on the screen display of the VANE-GL software.

The zero position of the speed regulator is at full stop, anti-clockwise direction. Turning the potentiometer clockwise, the speed of rotation increases.

Since the amount of 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 (cover figure) is in position 0, the manual twist chuck is still, independently of the position of the rotation speed regulator. In position 2, the twist chuck is rotated in the clockwise direction (direction always used during tests), at the speed given by the rotation speed regulator.

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.

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.

**WHEN PUSHING DOWN THE EXTENSION RODS, WITH VANE AND SLIP COUPLING TO THE NEXT TEST LEVEL, OR PULLING THEM UP, ALWAYS OPEN THE MANUAL CHUCK OF THE INSTRUMENT HEAD.**

**WHEN PUSHING DOWN OR PULLING UP RODS, 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.**

## **6. EQUIPMENT MAINTENANCE**

The Vane Instrument Head has to be regularly calibrated.

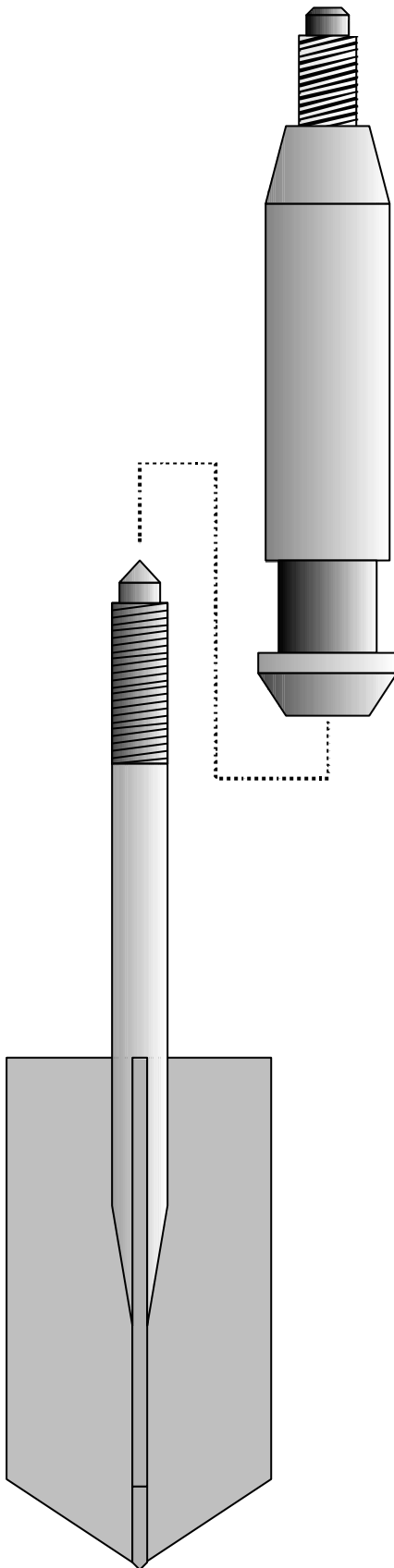
The downhole equipment has to be kept clean and dry, in particular keep the scraper and the Seeger-ring clean. These avoid the penetration of soil in the vane housing.

In the Eurocode model, the downhole equipment with the vane protection has to be cleaned and greased every day

## **7. MOUNTING OF DOWNHOLE EQUIPMENT AND TEST PREPARATION**

### *a. Standard Model*

The chosen vane with lower tapered ends (P.N. 00162, 00163, 00010, 00164) is connected to a slip-coupling (P.N. 00153) and then to Ø22 mm extension rods (P.N. 00884):



## 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 EVT 2000 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 EVT 2000 MUST BE LOCKED IN ITS OPEN POSITION DURING ALL PRESSING DOWN OR PULLING UP OPERATIONS**

*Figure 1.5: Vane with tapered lowerend of Standard model and slip-coupling*

### *b. Eurocode Model*

The vanes of the Eurocode model, with rectangular ends, are slid into a steel protection when pressed into the ground (Figure 1.6). 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 (P.N. 00153) 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 tightenings 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 copper 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 an gliding brass surface which will take the weight of the inner rods. Check carefully that the rod rotates freely. Lock the manual chuck on EVT 2000 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 simple steel plate with a Ø23 mm centre hole on the vane instrument holder. Put the Spring on top of the plate with extension rod through it and lock with the appropriate Rod Lock. Carefully pull the rod 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.
- 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.

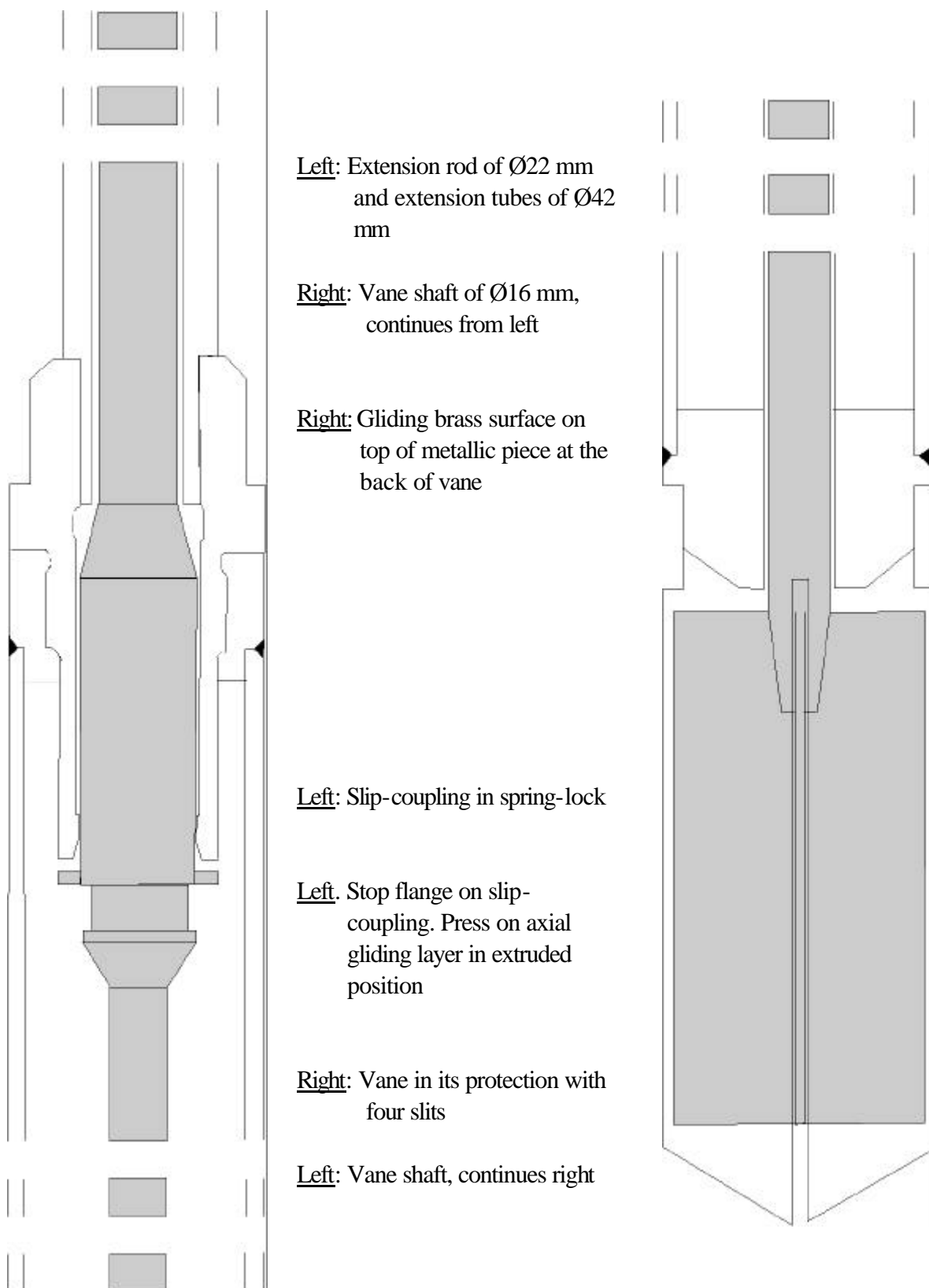


Figure 1.6: Vane Protection in cross-section, upper part, left, with slip-coupling in its spring lock. Lower part, right, with vane in its protection. Moving parts in grey.



- 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.

## **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. In the Eurocode 7, the vane has to rotate at a constant speed between 0,1 and 0,2 degrees per second (6-12 degrees per minute). For regulating the speed of rotation, see Use of Vane Instrument Head, Regulation of Rotation Speed, page 10

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 7. This may be done by rotating the vane with the putting the rotation speed regulator 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.

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 7.



*Fig 1.7: Eurocode vane in its protection left and in its extruded position*

# 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.**

Applied Torque		CLOCKWISE LOADING (Nm)	Anticlockwise loading (Nm)
(kpm)	(Nm)*		
10.19	10	10	10.26
20.38	20	20.01	20.41
30.57	30	30.01	30.45
40.76	40	40.01	40.44
50.95	50	50.06	50.41
61.14	60	59.94	60.36
71.33	70	69.87	70.27
81.52	80	79.80	80.07
91.71	90	89.88	89.88
101.90	100	99.55	99.55
	<b>S = 550</b>	<b>TOTAL/550=0.998</b>	<b>TOTAL/550=1.004</b>

\* 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

The vane constant  $C$  is calculated as follows:

Shear strength  $\tau = T \times C$

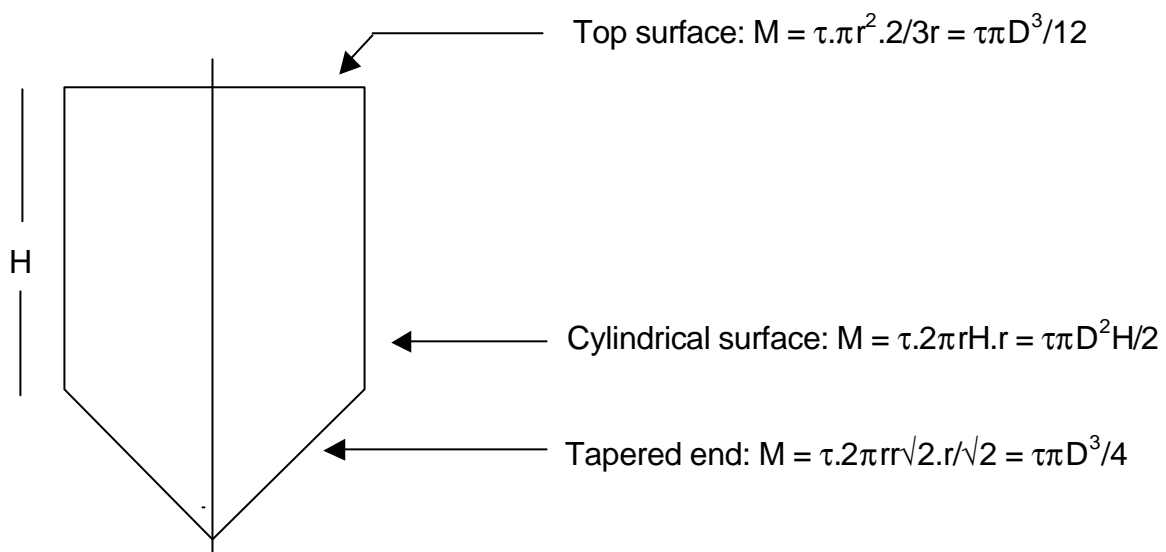
Where:

$\tau$  = 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



Where:

$D$  = measured diameter of the vane (cm)

$r$  = measured radius of the vane (cm)

$H$  = measured height of the vane (cm)

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

1. For vanes with tapered lower end ( $90^\circ$  apex), the constant  $C$  is equal to:

$$M = \tau p D^3/12 + \tau p D^2 H/2 + \tau p D^3/4$$

$$= \tau p D^2/2 (D/6 + H + D/2)$$

$$C = 2/p H D^2 \cdot 1/(D/6H + D/2H + 1)$$

For the different vane sizes provided by Geotech, the vane constant is as follows:

Number	Size (cm)	Constant (kPa/Nm)
1	11,0 x 5,0	2,0
2	13,0 x 6,5	1,0
3	17,2 x 8,0	0,5

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

$$M = 2 \cdot t p D^3 / 12 + t p D^2 H / 2$$

$$= t p D^2 / 2 (D/3 + H)$$

$$C = 2 / p H D^2 \cdot 1 / (D/3H + 1)$$

With a height to diameter relation of 2:1, the equation simplifies into:  $C = 273 \times 10^3 / D^3$

For the different vane sizes provided by Geotech, the vane constant is as follows:

Number	Size (cm)	Constant (kPa/Nm)
10	10,0 x 5,0	2,2
11	13,0 x 6,5	1,0

## APPENDIX 2: EXPLODED VIEW OF THE EUROCODE PARTS OF THE VANE APPARATUS

