Instruction Manual

SAAPZ Digital/Vibrating Wire Piezometer

Notices

Measurand shall have no liability for incidental or consequential damages of any kind arising out of the sale, installation, or use of its products. Please read this document and any notes and instructions carefully before proceeding with installation and operation.

ShapeAccelArray is covered by patents including: 6127672, 6563107, 7296363, WO 02/055958, WO 02/055958, WO 98/41815, 2472421 and others pending.

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1. Introduction

The SAAPZ is a vibrating wire piezometer which uses the same robust digital communication protocols as the SAAF or SAAR arrays. It can be read directly with a PC running the SAARecorder utility, from SAASuite, using an SAAUSB cable, SAA232-USB cable, or SAA Field Unit. Or the SAAPZ can be connected to Campbell Scientific CR800 or CR1000 loggers using either an SAA232 or SAA232-5 interface. SAAPZs are constructed using Geokon 4500S vibrating wire piezometers, providing the comfort of using a product with a long standing history of customer satisfaction while removing the need to use vibrating wire interfaces. In addition, unlike the case for standard vibrating wire piezometers, multiple SAAPZ units may have their cables connected together using an SAAPZ Splice Kit, reducing the number of cables running back to the logger.

2. Description

A photograph of the SAAPZ is shown in Figure 2.1 below. The SAAPZ has a 133 mm x 19.05 mm Ø vibrating wire piezometer which is connected to an SAA processor located in a 180 mm x 18.1 mm Ø processor pod which is approximately 58 cm (measured centre to centre) behind the piezometer. The assembly comes with 30 m of cable attached, though more can be attached during manufacturing. The entire assembly weighs approximately 0.6 kg (1.32 lbs). The SAAPZ can either have a 4-pin circular connector (as shown in Figure 2.1) for easy connection via an SAA Field Unit (or SAAUSB) or the ends can be left bare and the wires can be connected via the 5-pin terminal block on an SAA232 or (SAA232-5).

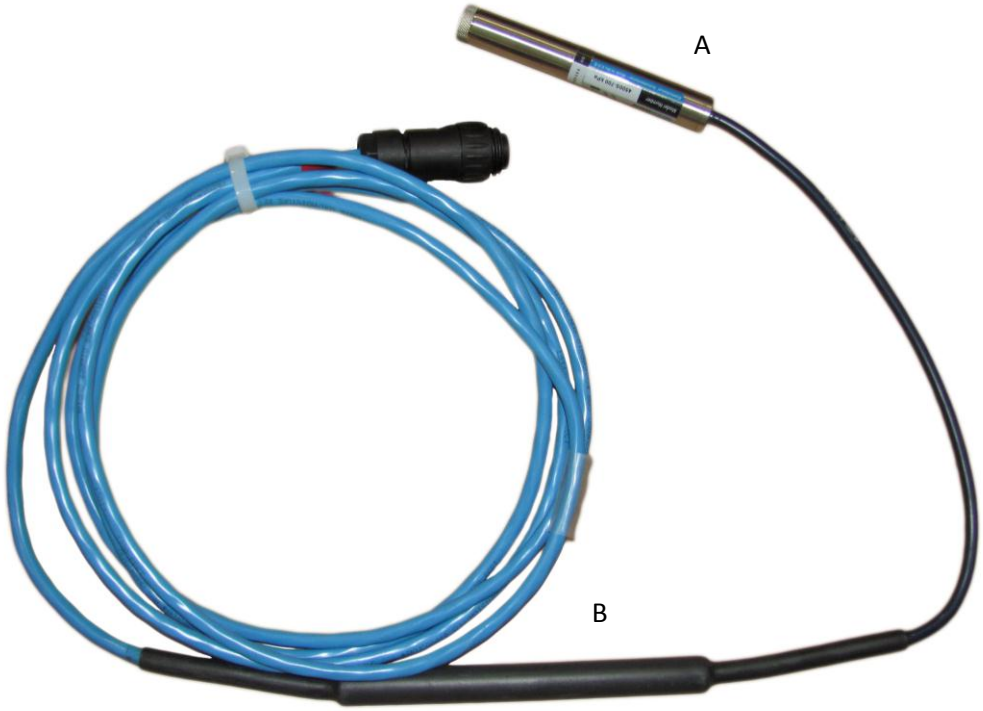

Figure 2.1 - SAAPZ Unit (A) Vibrating wire piezometer element, (B) Processor pod containing the SAAPZ processor and digital temperature sensor.

3. Taking Readings

Readings can be collected from SAAPZ units in one of two ways: the SAAPZ can be connected to a personal computer or laptop via an SAA Field Unit or an SAAUSB connection and read using the SAARecorder utility in SAASuite, or the SAAPZ can be connected to a Campbell Scientific data logger via a SAA232 or SAA232-5. **Note that in order to obtain initial readings from the SAAPZ use of the SAARecorder utility will be required. For more information on how to prepare the SAAPZ for initial readings, refer to Geokon's "Instruction Manual: Model 4500 series Vibrating Wire Piezometers". This manual can be downloaded at (http://www.geokon.com/products/manuals/4500_Piezometer.pdf).**

3.1 Operating with SAARecorder

SAAPZ units can be read with versions 4.48 or higher of the SAARecorder utility. If you do not have this version or higher, download SAASuite from the Measurand website in order to get the latest version of the SAARecorder utility (http://www.MeasurandGeotechnical.com/software.html).

3.1.1 Connecting SAAPZ to computer

There are three possible ways to connect an SAAPZ to a computer running SAASuite. The two most common ways are using an SAA Field Unit or SAAUSB. It is also possible to connect an SAAPZ to an SAA232 and to connect the SAA232 to the computer using a SAA232-USB cable. This last method is most commonly used when testing connections on earth stations using a PC.

3.1.1.1 SAA Field Unit

The SAAPZ unit can come with either a 4 pin circular connector or with the bare wires depending on customer needs. The SAA Field Unit shown in Figure 3.1(a) can be used to connect either style of SAAPZ to a computer. To connect the SAAPZ using the SAA Field Unit, follow the instructions provided in the SAA Field Unit Instruction Manual which can be downloaded from the Measurand Geotechnical website (http://www.MeasurandGeotechnical.com/products.html).

3.1.1.2 SAAUSB

An SAAPZ which has a 4-pin circular connector attached can be connected to a computer using an SAAUSB connector, shown in Figure 3.1(b). Connecting the SAAPZ and SAAUSB involves lining up the connectors correctly, pushing them together and turning the screw connections to close the gap. To ensure a good connection, turn the connector until it is finger tight, and make sure that the gap between the connectors does not exceed 1 mm (0.04"). The SAAUSB is then connected to a computer via a USB port. Power is supplied to the SAAUSB and ultimately the SAAPZ via a 12 V power supply which plugs into any AC outlet.

3.1.1.3 SAA232-USB

When an SAAPZ is to be connected to a data logger, it is still necessary to obtain the initial SAAPZ reading using SAARecorder. The SAA232-USB cable is used to connect the SAAPZ and a computer running SAARecorder via an SAA232 or SAA232-5. The SAA232-USB is included in all Earth Stations sold by Measurand. If you have not purchased an Earth Station from Measurand, the cable is available for a small fee, please contact Measurand for more details.

The SAA232-USB cable is shown in Figure 3.1(c). The green 4-pin connector plugs into the top receptacle on the SAA232 or SAA232-5. The SAAPZ cable is then wired into a 5-pin connector which is located on the SAA232 (see the wiring key on the side of the SAA232 or SAA232-5). Power is supplied to the

Figure 3.1: a) SAA Field Unit, (b) SAAUSB cable connection, (c) SAA232-USB cable connection

SAA232 and SAAPZ by connecting the red (12V) and black (Ground) wires from the SAA232-USB cable to available power ports on either the data logger or the SAAReg charge regulator. The SAA232-USB cable is then connected to a computer using the USB connector.

3.1.2 Using SAARecorder to read SAAPZ data

Once the SAAPZ is connected to the computer, it is possible to read the SAAPZ unit using the SAARecorder utility. The menu options for reading the SAAPZ are described below. For further details on how to use SAARecorder, please read the SAARecorder Manual included in SAASuite.

3.1.2.1 Setting SAAPZ output options

The SAARecorder utility defaults to calculating the SAAPZ pressures using a polynomial equation provided by Geokon. If you wish to use the linear equation provided by Geokon, you must go to the menu option **Options | Advanced | Piezometer Options.** This will open the window shown in Figure 3.2. Once the window is open, select "Use Linear Calibration Coefficients" from the drop down box at the bottom.

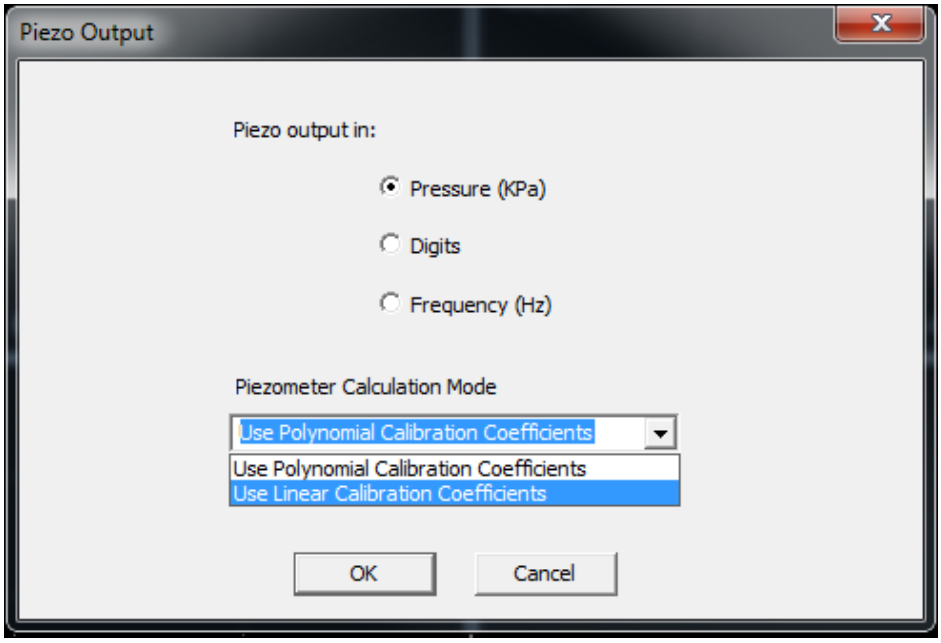

Figure 3.2: SAAPZ piezometer output window

3.1.2.2 Calculating pressures using polynomial calibration

When "Use Polynomial Calibration Coefficients" is selected, SAARecorder uses the following polynomial equation given by Geokon for calculating pressures:

$$P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$$

Where P = Pressure (kPa)
A, B, and C = polynomial gauge factors
K = thermal factor
R = reading in digits
T = temperature
S = barometric pressure

The C polynomial gauge factor is calculated by setting the pressure to zero and inserting the initial field zero reading into the polynomial equation. SAARecorder lumps together the C and (S_1-S_0) into one offset value.

In order to set this zero offset, go to menu option **Calibrations | Advanced | Calibrate Piezometer Offset.** If you have more than one SAAPZ connected at the same time, you will be prompted to select the SAAPZ for which you want to set the zero offset. You can set the zero offset for a single SAAPZ unit, or for all connected SAAPZ units at once. Again note, due to the construction of the piezometer element, it takes between 5 – 15 minutes for the temperature to equilibrate; setting the zero offset should be done after the temperature has finished equilibrating. Once the calibration has been completed, a backup copy of the updated SAAPZ calibration file should be made in case something happens to the computer containing the file.

The polynomial equation will return the most precise measurement of pore pressure, but it should be noted that in cases where only the changes in pore pressure are being monitored, either the polynomial or the linear equation will return acceptable results.

3.1.2.3 Calculating pressures using the linear equation

When "Use Linear Calibration Coefficients" is selected, SAARecorder uses the following linear equation given by Geokon for calculating pressures:

$$P = G(R_0 - R_1) + K(T_1 - T_0)$$

Where P = Pressure (kPa)
G = linear gauge factor
K = thermal factor
R = reading in digits
T = temperature

Note that SAARecorder does not take into account the barometric correction. In order to use this equation, it is necessary to obtain an initial field reading. Setting the initial reading is done in two steps.

To set the initial reading, first make sure that SAARecorder is using the linear equation (see Section 3.1.2.1). Once this is done go to menu option **Calibrations | Advanced | Calibrate Piezometer**

Offset. If you have more than one SAAPZ connected at the same time, you will be prompted to select the SAAPZ for which you want to set initial reading. You can set the initial reading for a single SAAPZ unit, or for all connected SAAPZ units at once. Note, due to the construction of the piezometer element, it takes between 5 – 15 minutes for the temperature to equilibrate; setting the initial reading should be done after the temperature has finished equilibrating. If you plan to use a logger to collect data from an SAAPZ, and you prefer to use linear calibration, you can choose the Linear Calibration in **Calibrations | Advanced | Calibrate Piezometer Offset.** Once the calibration has been completed, a backup copy of the updated SAAPZ calibration file should be made in case something happens to the computer containing the file.

3.1.2.4 Viewing and saving data

It is possible to view the numeric data collected from the SAAPZ using the **View | Numeric Data** menu option. This will open a data table window as shown in Figure 3.3. The data table can display the SAAPZ piezometer data in Digits, Frequency, Pressure (kPa), as well as the SAAPZ temperature.

To view a graph of the data, use the **View | Graph Data** menu option. This will open a data selection box, as shown in Figure 3.4. Select the SAAPZ which you wish to view and save data from and click the 'Add' and then the 'Ok' buttons. This will produce a graph as shown in Figure 3.5.

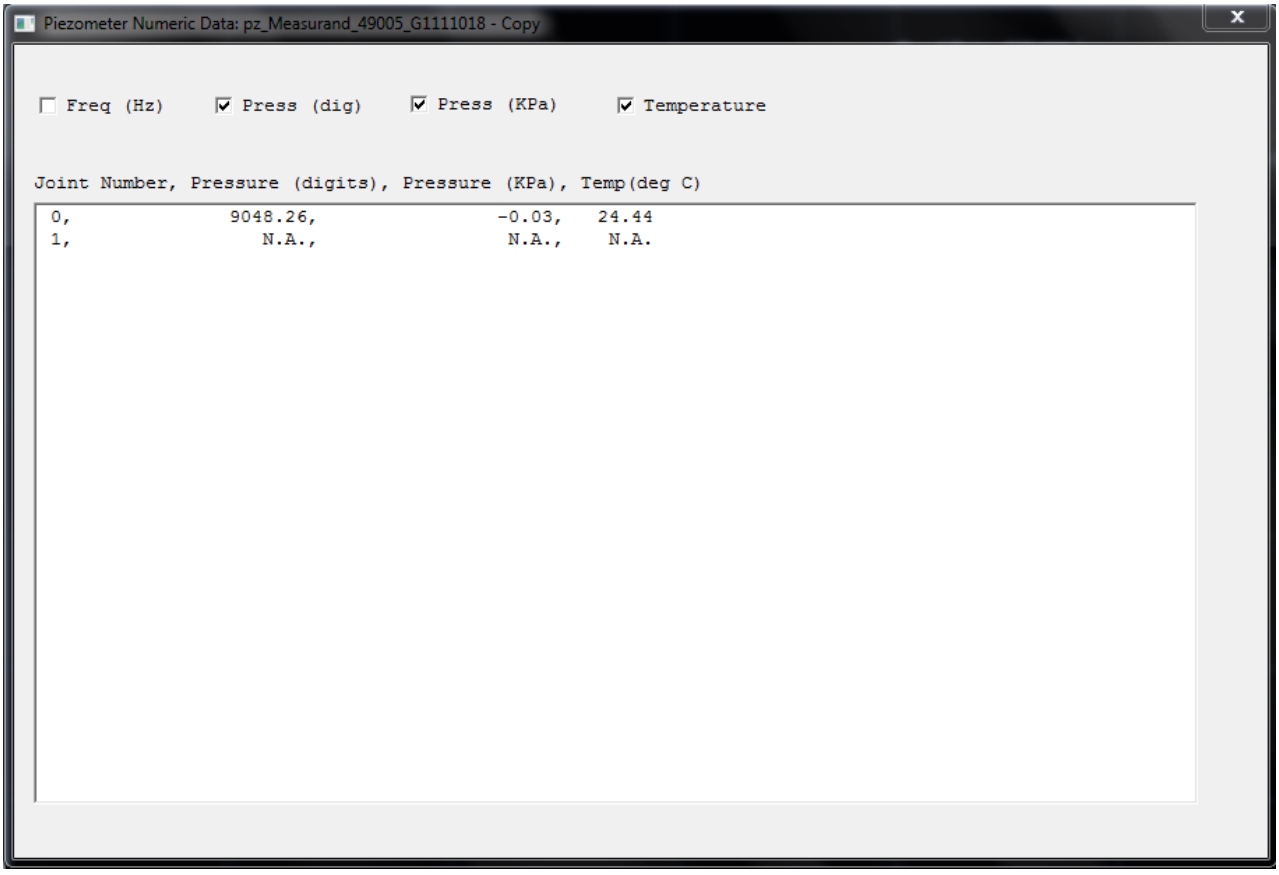

Figure 3.3: Numeric data table in SAARecorder

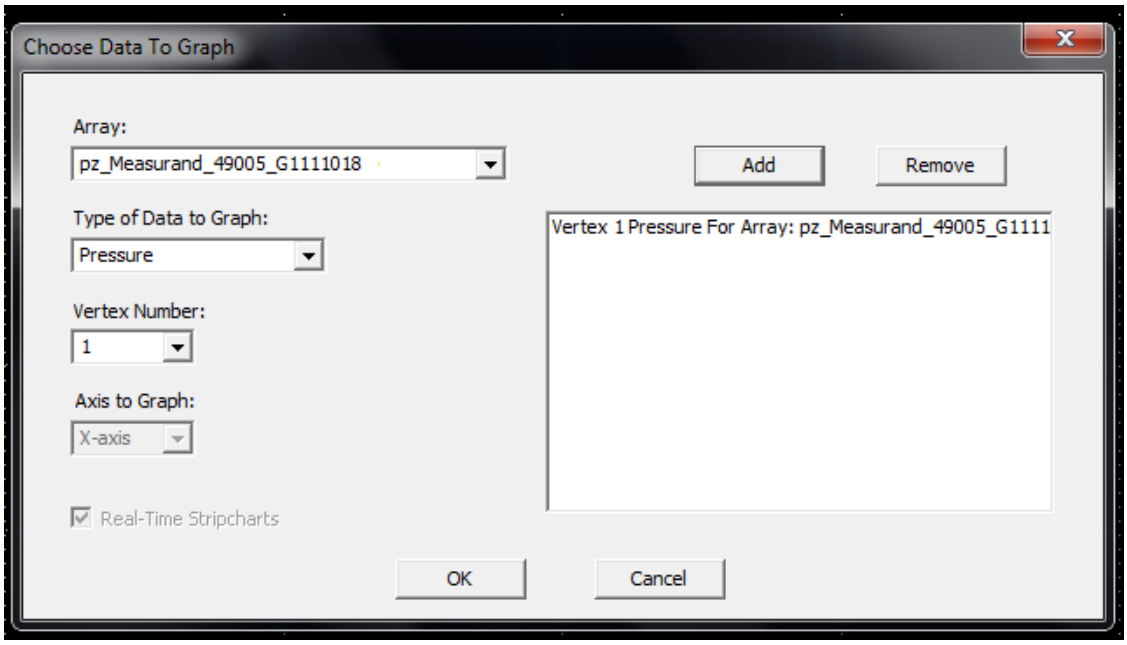

Figure 3.4: Graph data selection in SAARecorder

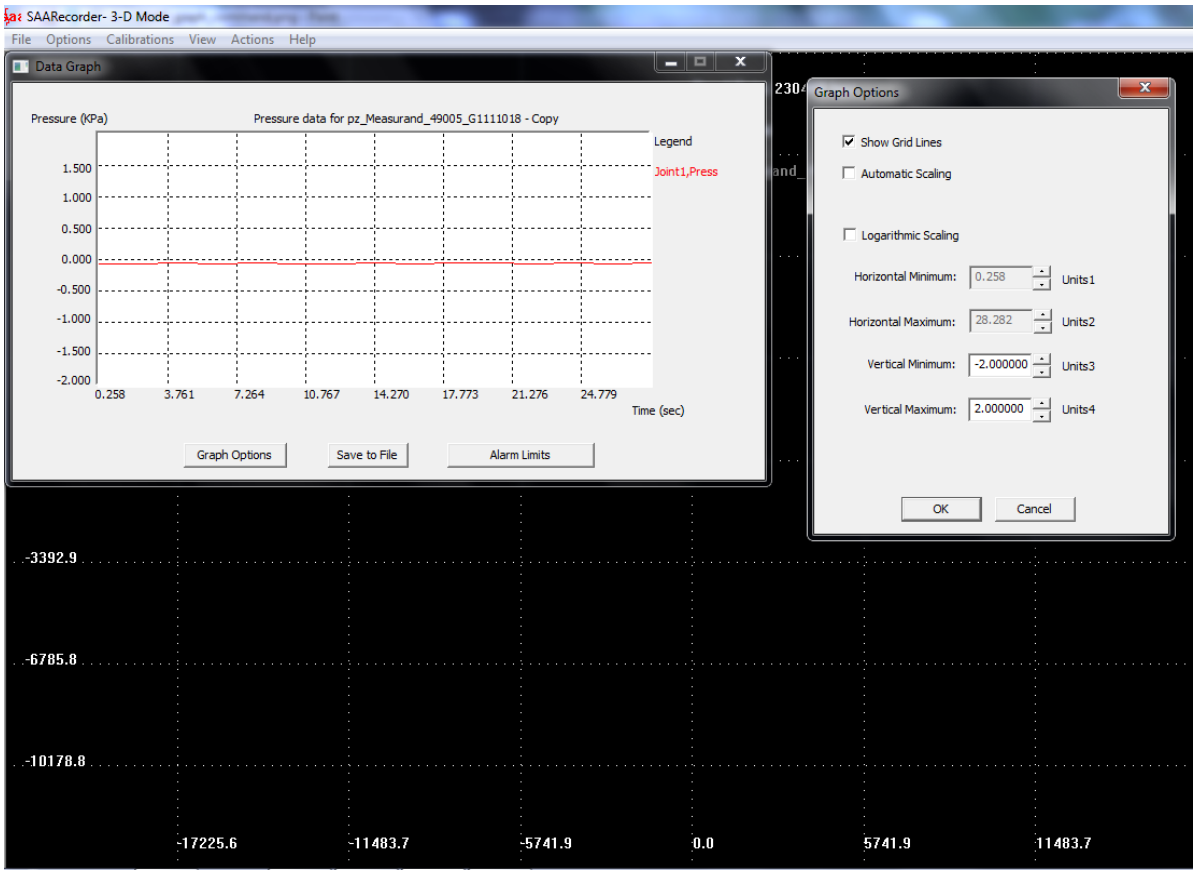

Figure 3.5: Data graph window and Graph Options window.

Once the graph is open, it is possible to change the scaling options by clicking on the 'Graph Options' button. It is also possible to save data from the SAAPZ by clicking the 'Save File' button then entering the desired file name. Data will be collected until the 'Close File' button is clicked. A sample data file is given is Appendix A.

3.2 Operating with CR800/CR1000 data loggers

Once the initial field reading is taken using SAARecorder, it is possible to connect the SAAPZ to a CR800 or CR1000 data logger. A logger program can be written using the SAACR File Generator tab in SAASuite. If necessary, the logger program can be modified using the Loggernet 'CRBasic Editor' utility in order to add other sensors to the logger. See the "Integration of ShapeAccelArray and Campbell Scientific CR800/CR1000 Data Loggers" user guide available for download from Measurand's website (http://MeasurandGeotechnical.com/products_data_loggers.html) for more information regarding logger programming.

SAAPZ and SAAF data stored on the logger is composed of raw data counts. It must be converted into engineering units using the SAACR_raw2data utility in SAASuite. For more information on this utility, please read the manual included with the software installation. Once the data has been converted, it can be viewed using the SAAView utility in SAASuite. Data tables are also created by the conversion program, these can be imported into programs which accept text file imports.

4. Installation

4.1 Preliminary tests

The SAAPZ uses a Geokon 4500 series vibrating wire piezometer in its construction. As such, preliminary testing should be done in accordance with the instructions provided in Geokon's "Instruction Manual: Model 4500 series Vibrating Wire Piezometers". This manual can be downloaded from the Geokon website (http://www.geokon.com/products/manuals/4500_Piezometer.pdf).

Note that it is imperative that you establish an initial reading for each piezometer prior to installing these as this reading will be used in all subsequent data reduction. Geokon outlines several methods with which to prepare the piezometer for taking initial readings. Refer to the Geokon Instruction Manual for more details.

4.2 Installation in boreholes

Individual SAAPZs can be installed using conventional sand and bentonite grout installation methods. However, if more than one SAAPZ is installed per borehole location, it is recommended that the SAAPZ be installed fully grouted in. This is consistent with the SAA installation methods which are currently outlined in the SAA installation guide. For recommendations regarding bentonite cement grout mixes, see the Geokon Instruction Manual.

When multiple SAAPZs are installed in a single borehole, the SAAPZs are attached to the outside of the 27 mm ID conduit used for carrying an SAAF prior to inserting the conduit into the ground. This allows for easy control of the piezometer depth. The piezometer is typically placed with the element pointing upwards, but it can be installed with the element pointing down. The cable is then run up the PVC

Figure 4.1: SAAPZ mounted to PVC conduit.

conduit. Piezometers and cables should be carefully cinched to the PVC conduit, keeping spacing between cinch points within 50 cm. If desired, the up to three individual SAAPZ cables and one SAAF cable can be spliced together into one cable. This single cable is then connected to the SAA232 or SAA232-5. For added protection against power surges from nearby lightning strikes, it is recommended that an SAASPD be used, see the SAASPD manual for more details.

4.3 SAAPZ Splice Kit

Up to four SAAPZs, or three SAAPZs and one SAAF may have their cables connected together using an SAAPZ Splice Kit, with a common single cable running from the splice point to the logger. Note that in some cases it may be possible to join more than four instruments onto one cable, contact Measurand for more information. This single cable can go into an SAA232 or SAA232-5 port.

The SAAPZ splice kit shown in Figure 4.2 consists of the following items: an SAATERM board with 5 terminal blocks, a clear plastic potting tube, and Scotchcast 2131 B two part potting compound.

Figure 4.2: SAAPZ Splice Kit.

To use the splice kit, use the following steps:

1. Assemble all the wires you will be splicing together, the splice kit, some wire cutters and wire strippers.

2. Remove approximately 25 mm to 40 mm of the cable insulation to reveal the wires. Sand the cable behind the wires for (sanded section should measure approximately 25 mm).

3. Strip the insulation from the wires in the cables. Be careful to remove between 5.5 mm and 7 mm of insulation. Removing too much insulation could lead to bare wires touching causing a short, removing too little insulation could lead to bad contact with the terminal block (see Figure 4.3 for an example).

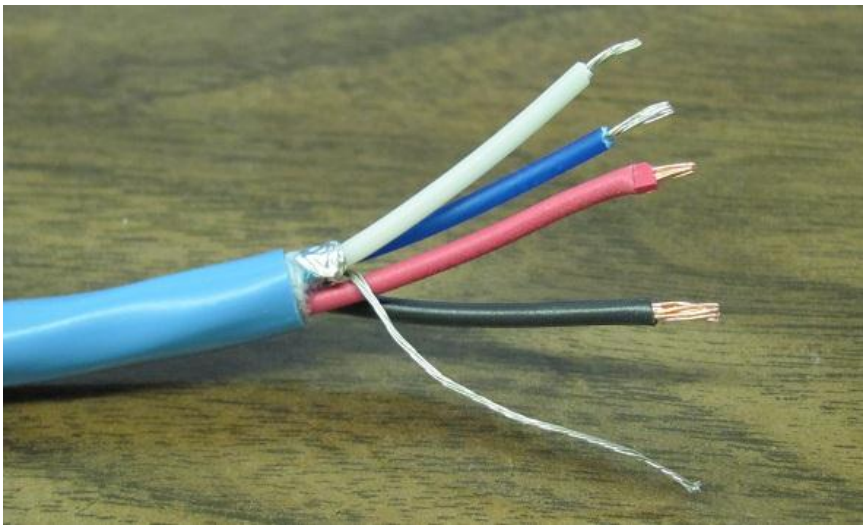

Figure 4.3: Wires stripped of insulation, note the red wire was not stripped back far enough.

4. Screw wires into the SAATERM terminal blocks using the same wiring scheme as shown on the SAA232. Start wiring at Block 1 (Figure 4.4) and continue through to block 5 being careful to arrange the cables in as small a bundle as possible.

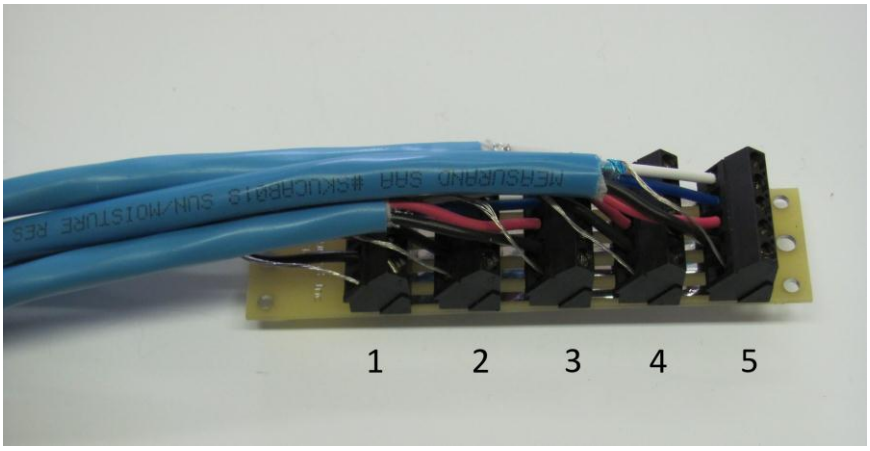

Figure 4.4: Wiring SAATERM for SAAPZ splice.

5. In colder weather make sure to warm up the potting compound before mixing, following the recommendations on the package. Mix the two part potting compound as per the instruction on the package (Figure 4.5).

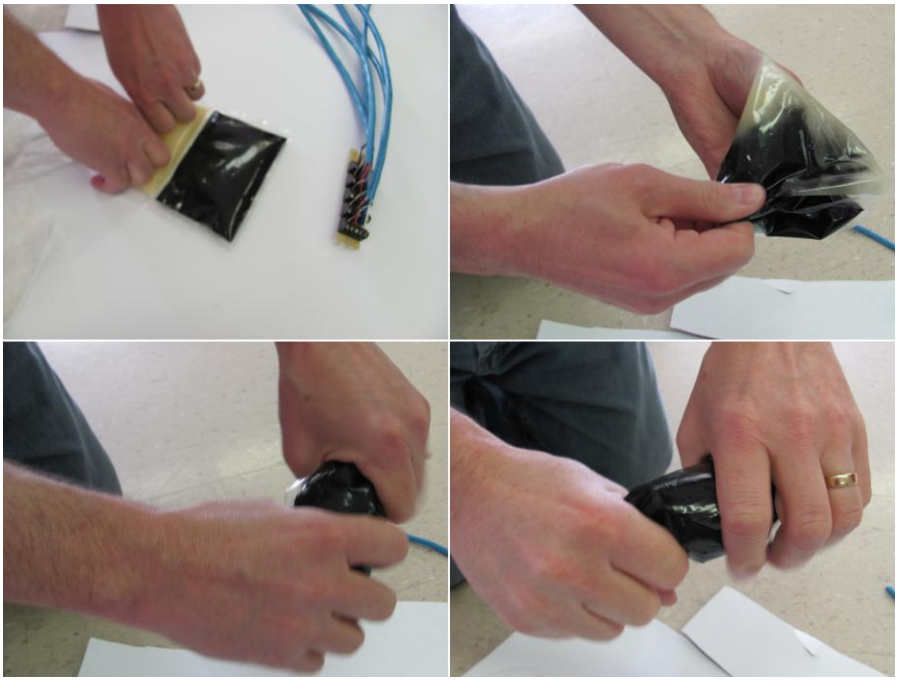

Figure 4.5: Mixing potting compound. Note, thoroughly mix the potting compound for 1 minute before using.

6. Pour the potting compound into the potting tube. (Figure 4.6)

Figure 4.6: Potting SAATERM with SAA and SAAPZ cables spliced together.

7. Insert the SAATERM board and cables into the potting tube. Make sure that the potting compound covers the cables such that there are no exposed wires. (Figure 4.6)

8. Attach the completed splice to the PVC conduit using zip ties, or dig a small hole next to the conduit and place the potting tube upright in the hole.

9. The potting compound will set within 15 minutes and will finish curing within 24 hours. To protect the potting compound during this time, you may wish to tape the top of the splice kit closed using electrical or duct tape.

5. Specifications

Dimensions:	19.1 mm Ø x 133 mm (piezometer), 18.1 mm Ø x 180 mm (processor pod)
Weight	0.6 kg
Standard Ranges	-100 kPa to 350 kPa; -100 kPa to 700 kPa
Over Range	2 x rated pressure
Resolution	0.025% F.S.
Accuracy	± 0.1% F.S.
Linearity	<0.5% F.S.
Temperature Range	-20°C to 80°C
Thermal Zero Shift	<0.05% F.S./°C
Diaphragm Displacement	<0.001 cm^3 at F.S.
Power	12 V@ 8 mA

Appendix A – Sample SAAPZ Data File Collected Using SAARecorder