

# MBAS-A

## Analogue Multistation Borehole Acquisition System

### Operating and Maintenance Instructions



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## Introduction

High-resolution P-wave tomographic investigations between boreholes are routinely applied for the exploration of development sites considered for larger building projects, e.g., power stations, dams and high-rise buildings. However, the geotechnical benefits of P-wave tomography are rather limited and information about S-wave velocity distribution is additionally required to derive geotechnically relevant parameters, such as dynamic soil parameters. Up to now, only little efforts have been made to develop equipment enabling the competitive acquisition of S-wave crosshole tomographic data.

The Multistation Borehole Acquisition System (MBAS-A) is designed for efficient recording of S-waves in boreholes at different levels. The system is analogue and has to be connected to a seismograph. Each station is equipped with a 3C sensor arrangement and can be pneumatically coupled to the borehole wall by an air packer. All sensor components are aligned to each other. For orientation a magnetic compass is mounted within the bottom station.

The MBAS-A system consists of

1. Multi-core cable on drum with eight stations (each with tri-axial sensor arrangement)
2. Air packers mounted to the stations
3. Twin air hose on drum with manometers

### 1. Geophone stations

The MBAS-A consists of eight 3C stations separated 1 m or 2 m (see figure 1). Stations are connected to each other with a rotary pipe string. In this way, all seismic channels are aligned to each other.



Fig. 1: MBAS-A stations

**Depth reference (z=0m) is lowest station.**

Each station contains three sensors (X,Y,Z) in a tri-axial arrangement. The X-sensor points in the opposite direction of the air packer, the Y-sensor is 90° off and Z is vertical (see figure 2).

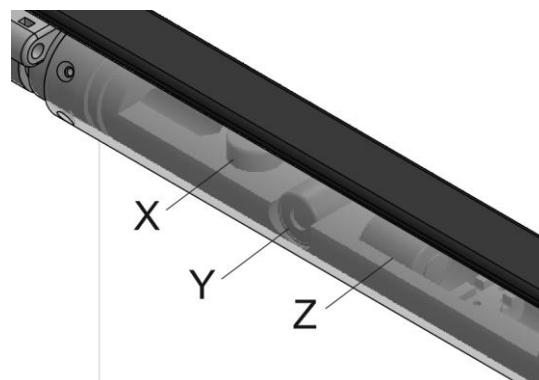


Fig. 2: Sensor orientation

The sensors give positive raising signal in direction according to the sensor assembly (see figure 3, a seismic impulse towards the marker line produces a positive rising signal).

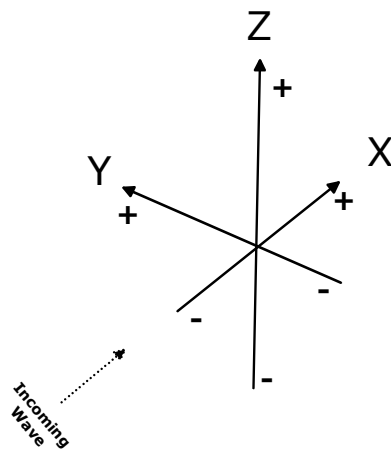


Fig. 3: Sensor polarity

Table 1 shows the wiring scheme.

Table 1: MBAS-A wiring scheme

MBAS-A		
Channel	Comp	Station
1	X	1 (lowest)
2	Y	
3	Z	
4	X	2
5	Y	
6	Z	
7	X	3
8	Y	
9	Z	
10	X	4
11	Y	
12	Z	
13	X	5
14	Y	
15	Z	
16	X	6
17	Y	
18	Z	
19	X	7
20	Y	
21	Z	
22	X	8 (topmost)
23	Y	
24	Z	

## 2. Compass Unit

Main part of the compass unit is a two-component magnetometer sensor placed in a non-magnetic housing. The compass unit is mechanically connected to the lowest geophone station.

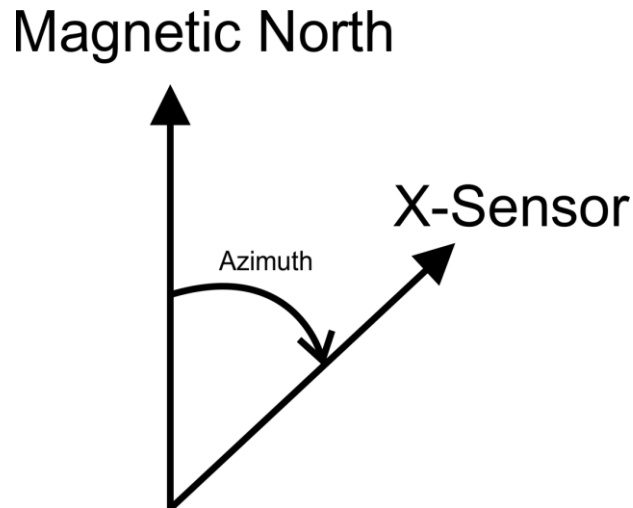


Fig. 4: Schematic sketch showing angle measure

The angle between magnetic north and the direction of the X-sensor can be correctly measured and is displayed on the surface unit. The magnetic sensor is connected to the display box at surface via three pairs of borehole cable wires.

Resolution and accuracy of the compass readings is 5°. A display at the drum shows the measured magnetic azimuth of the downhole sensor.



Fig. 5: Compass Display at drum

USB	→	USB Interface to read magnetic azimuth using PC
ON/OFF	→	Switch on/off display
CHARGING (CHARGER)	→	Adapter to charge the internal batteries of the compass
LIGHT	→	Press shortly once display will be illuminated for 30sec → Press longer, illumination is continuously (press again illumination stops)
RESET/CAL (Calibration)	→	Press shortly compass is reset (resets basic values) Press longer (~ 2 sec) hard iron calibration is made. For calibration hold BGK vertical and turn twice within the calibration time (20sec).

### 3. Air packer system

Air is supplied through a twin air hose. One hose supplies air to the lower four stations (1-4) and the other hose supplies air to the upper four stations (5-8). Air pressure can be controlled through two independent manometer gauges. A schematic diagram is shown in figure 6.

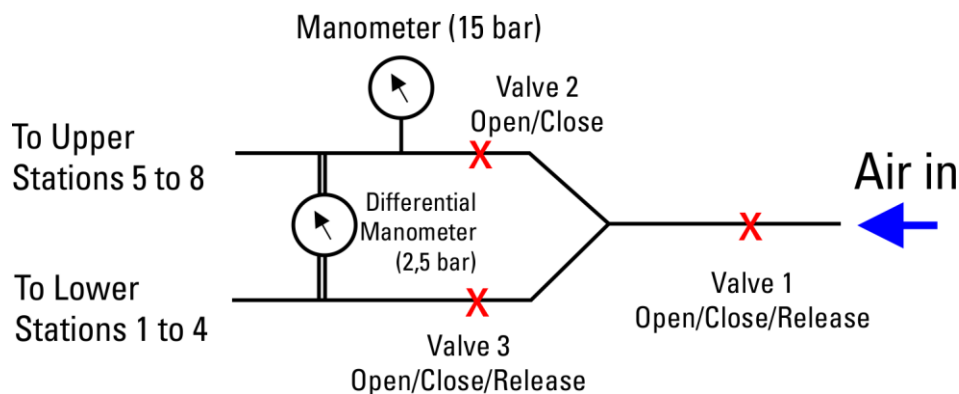


Fig. 6: Schematic diagram for air supply

**Depth reference (z=0m) is lowest station #1.**

Measurements above water table

If measurements are carried out above the water table all air packers (from 1..8) are exposed to atmospheric pressure. In this case a uniform pressure of 1 to max. 1.5 bar can be applied to all air packers to clamp to 3inch holes.

Measurements below water table

If measurements are carried out below water table each consecutive air packer is exposed to a pressure difference of 0,2 bar (= 2m station spacing) or 0,1 bar (= 1m station spacing) due to hydrostatic pressure.

Air can be supplied separately either to the lower four stations (1-4) or to the upper four stations (5-8).

The air bladders are designed to allow the uniform expansion under different hydrostatic pressure due to different rubber material.

Fig. 7 shows the schematic diagram of the air packer system. Lower four stations (1-4) are in orange colour, upper four stations (5-8) are shown in yellow colour.

According to the hydrostatic pressure the pressure at the lowest station #1 is P2 and  $P2 = P1 + 0.8\text{bar}$ .

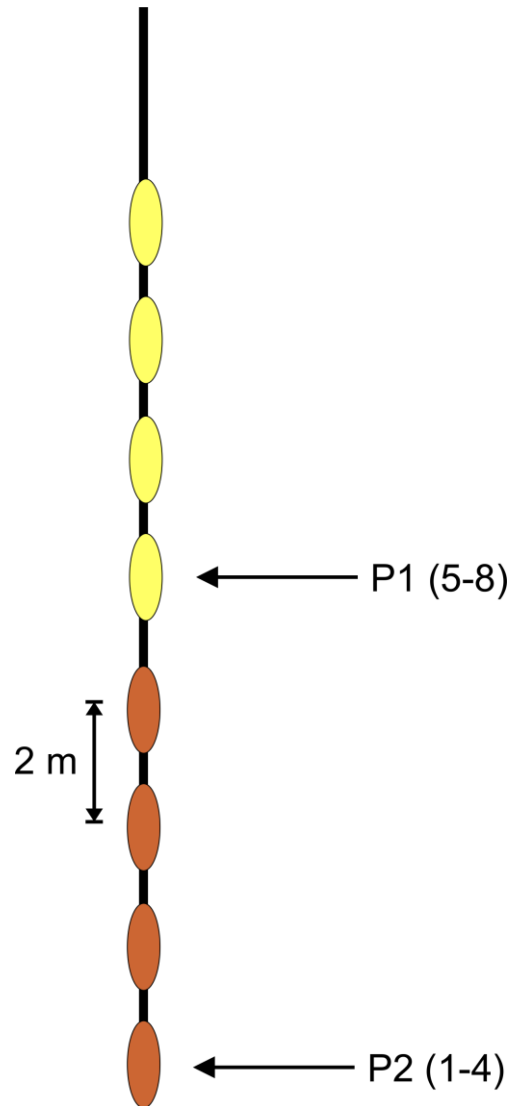


Fig. 7: Sketch for pressure design



### 3.1 How to apply pressure

Air is supplied through a twin assuming the water table is at depth  $Z_{\text{water}}$ . We recommend the following procedure to apply air to the bladders in 3 inch boreholes. Station spacing is 2m, i.e. pressure difference between stations below groundwater is 0.2 bar. Clamp cable with cable clamp.

1. Calculate relevant “hydrostatic depth” for station #5 (pressure rating P1) as follows:

$$Z_{P1} = Z - 8 \text{ m}$$

where Z is the reading at the cable marking (= top casing to lowest station).

2. Calculate hydrostatic pressure P1 at  $Z_{P1}$  is

$$P1 = (Z_{P1} - Z_{\text{water}}) * 0.1 \text{ bar}$$

where  $Z_{\text{water}}$  is the water depth below reference level (= top casing).

3. Open all valves 1, 2 & 3 (see figure 6)
4. Apply over pressure  $P1_+$  with  $P1_+ = P1 + 1.5 \text{ bar}$ . At this pressure all upper stations 5-8 are clamped.
5. Close valve 2.
6. Apply pressure via valve 1 to lower stations 1 – 4 until differential manometer shows **+0.8 bar**.
7. At this pressure all lower stations 1-4 are clamped.
8. Close valve 3 & 1.
9. Start acquiring data (it is recommended to release the cable a little bit to avoid guided waves along the cable).

### 3.2 How to release pressure

Following the procedure to release pressure from packers is described.

1. Open valve 3 and release pressure until differential manometer shows “0”
2. Open valve 2
3. Open valve 1 and release pressure to clamp off all packers.

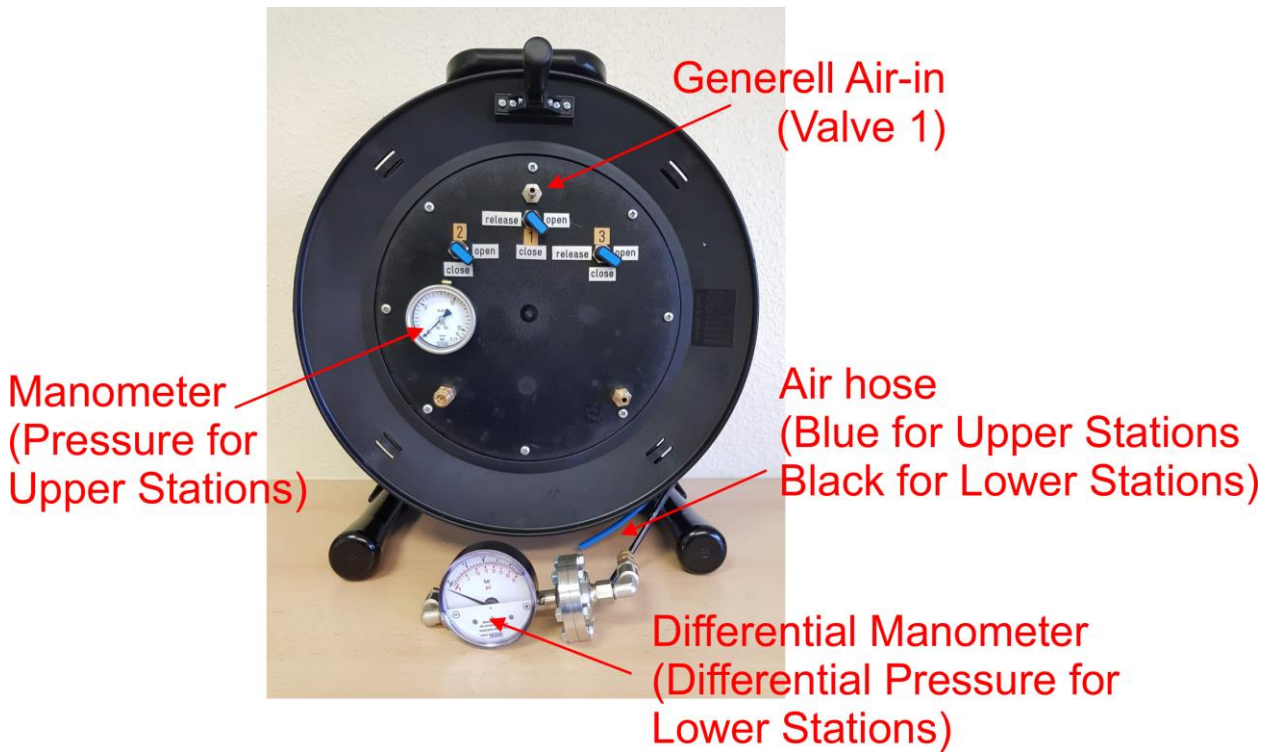


Fig. 8: Air supply on drum



Fig. 9: Differential manometer (left) and connected to drum (right)

Air packers are supplied as spares with colour coding (see figure 10).

Black: Use for station 1 & 2 and 5 & 6

Green: Use for station 3 and 7

Red: Use for station 4 and 8



Fig. 10: Colour coded air bladders

#### 4. Maintenance

No special maintenance instruction for the seismic sensor system. Seismic sensors do have a natural frequency of 10Hz +/- 2.5%. Coil resistance is 375 Ohm +/- 2.5% with a spurious frequency of larger 240Hz.

Do not bend seismic cable below a radius of 20 cm. Do not cut cable, do not override.

Charge internal compass batteries on regular basis.