Impulse Generator IPG5000 and P-wave sparker SBS42 & S-wave source BIS-SH & BIS-SV

Geotomographie GmbH, Am Tonnenberg 18, 56567 Neuwied (Germany)
Tel.: +49 2631 778135 email: info@geotomographie.de

Content

0. Precautions for operating high voltage equipment type SBS42 and BIS-SH/SV

Like other seismic sources such as explosives, air guns, or weight-dropping systems, operating an electrical spark or other high-voltage impulse sources requires several precautions. The most important precautions are:

1. **Impulse generator operation by authorised personnel only.**
2. **Do not connect or disconnect cables while the impulse generator is switched ON. Switch the impulse generator OFF before disconnecting cables or connectors.**
3. **Do not touch cables or the borehole sources the impulse generator is operating.**
4. **Ground the impulse generator with the ground hook before switching ON.**
5. **Do not expose the impulse generator or connectors to water or dust.**
6. **Do not charge the impulse generator over 5.300 V!**
7. **Do not open the impulse generator or remote control. Maintenance must be carried out by authorised personnel.**
8. **In case of any malfunction or emergency, switch OFF the impulse generator by pressing the red OFF button on the generator or turning the key switch OFF on the remote control.**

Moreover, observe the following:

- Check cables and connectors for damage before and after each field survey.
- Do not use damaged cables.
- Do not open the impulse generator when it is connected to a power source.
- Repairs and maintenance should only be carried out by authorised personnel.
- All connections should be **dry** to avoid a flashover inside the connector. Ensure that no water, e.g. rain, gets into the connections.
- If an impulse is released without a spark, the cable can be charged with high voltage like a small capacitor. This energy must be dissipated by switching off the pulse generator. Check this by observing the HV meter. Wait until the voltmeter on the pulse generator shows a voltage close to 0 volts!
- High voltage will discharge slowly (about 1 - 2 minutes). Wait until the voltmeter at the impulse generator reads 0 volt!

1. Impulse generator IPG5000

The impulse generator IPG5000 is the high-voltage power supply for the seismic borehole sources SBS42 BIS-SH or BIS-SV. Figure 1 shows the impulse generator and its remote control unit (RCU).

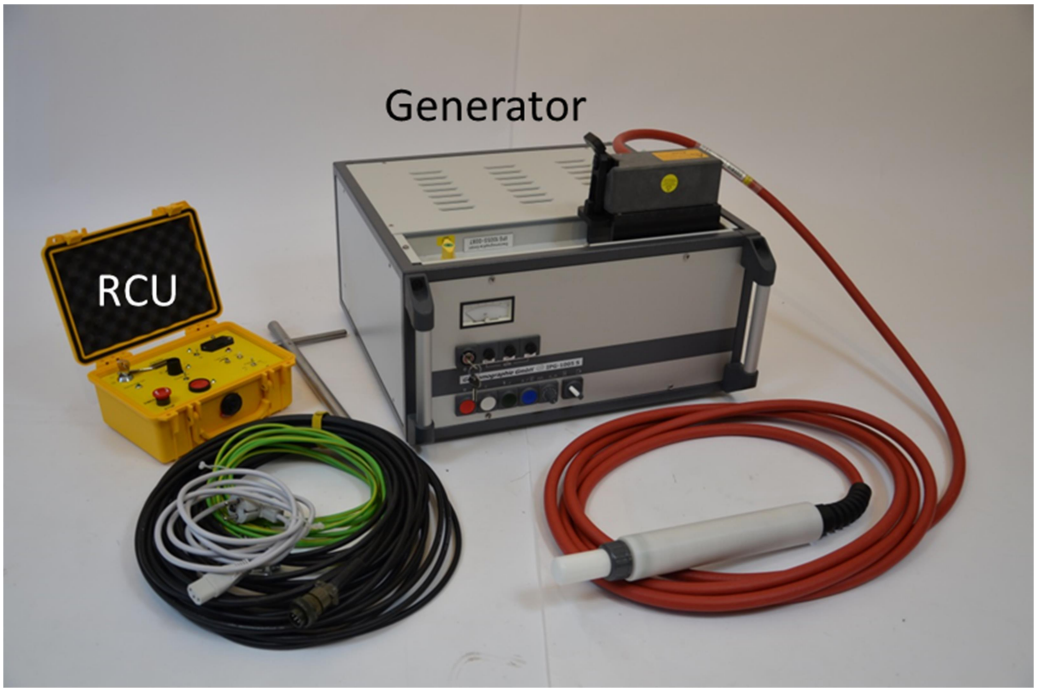


Figure 1: Impulse generator IPG5000 and remote control unit (RCU).

The IPG5000 needs to be powered from an external 230 V / 50 Hz or optional 115 V / 60 Hz supply. If the voltage drops below 210 V, the system will not operate. The output energy of the IPG5000 is 1000 J @ 5000 V.

Impulses can be released in single or continuous mode using either the remote control unit (RCU) or the controls on the IPG5000 control panel. The HV output has no direct contact with the generator housing, i.e., the terminals +HV and -HV are connected to the housing and ground via two resistors of 15 MΩ each.

The generator should be operated at a distance from the seismograph to avoid electromagnetic interference. Avoid the crossing of cables.

Attention:

- **The impulse generator must be protected from all moisture, e.g., rain and dust!**
- **Before switching the generator "ON", the ground terminal of the generator must be connected to the ground using the grounding hook via the yellow-green cable. Add water to the grounding hook to ensure good contact with the ground if the ground is very dry.**

1.1 Connecting and setting up the IPG5000

The following accessories are supplied for the operation of the impulse generator (see Figure 2):

1. Grounding hook with cable (colour **yellow**/**green**)
2. Power supply cable (**grey**) with connector (type suitable to national standards)
3. Remote control unit with cable (**black**)
4. High-voltage surface cable (large **red** cable) for connection between the impulse generator and borehole cable with a length of approx. 6 m. Equipped with a quick coaxial connector (sleeve part) for connection to the surface connector of the borehole coaxial cable.

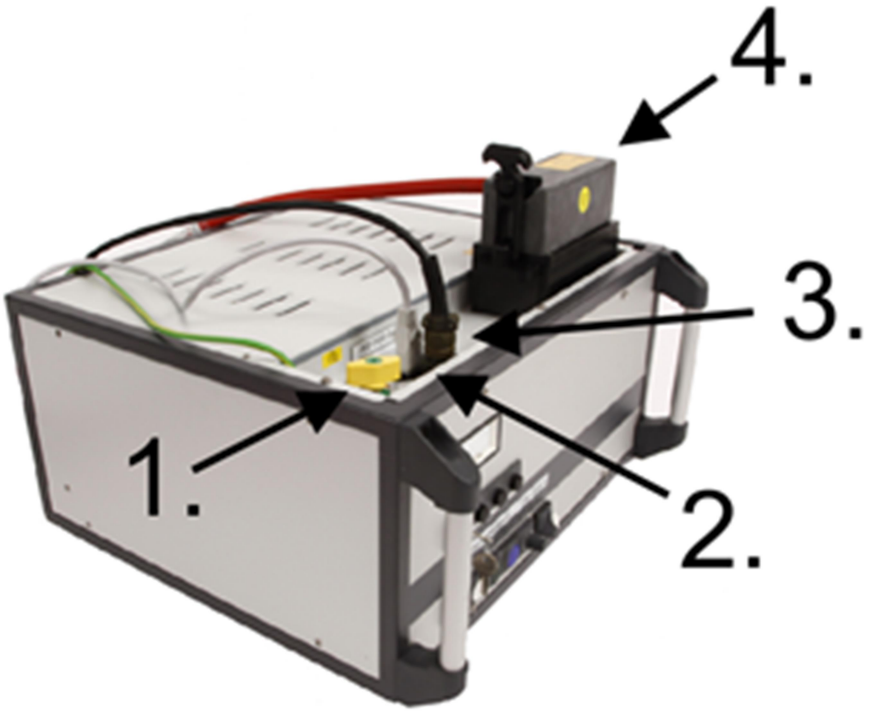


Figure 2: Cable connections at the IPG5000

Follow the instructions below to connect the cables to the IPG5000.

- ➔ Connect the cables to the IPG5000 in the same order (from 1 to 4).
- ➔ Do not connect the power cable to the external power supply. This must be the last connection after all other connections are in place.
- ➔ Disconnect the cables from the IPG5000 is in the same order (from 4 to 1), but first switch off the unit disconnect the VAC.

➔ NEVER disconnect during operation or while the unit is charging.

Next, the borehole sources SBS42, BIS-SH, and BIS-SV can be connected to the IPG5000 using the big red HV cable (see chapters 5.1 and 5.2)

Figure 3: Details of the connecting points on the rear of the IPG5000

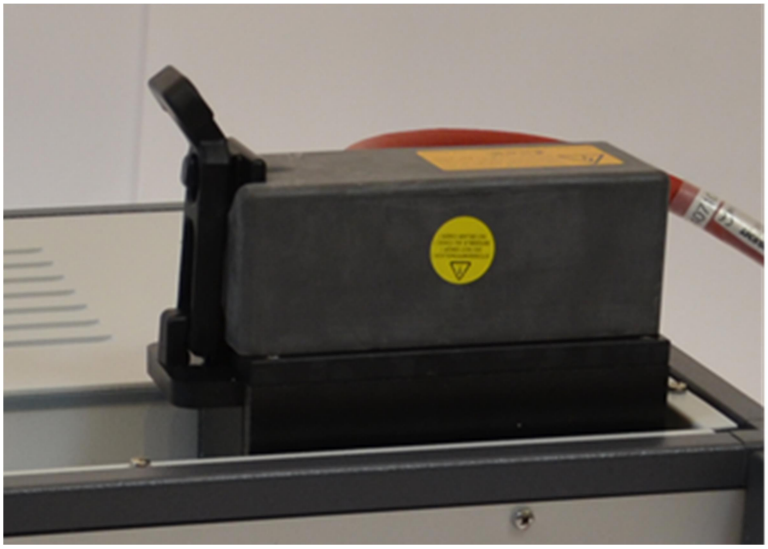


Figure 4: Rubber fixing of HV connector on IPG5000

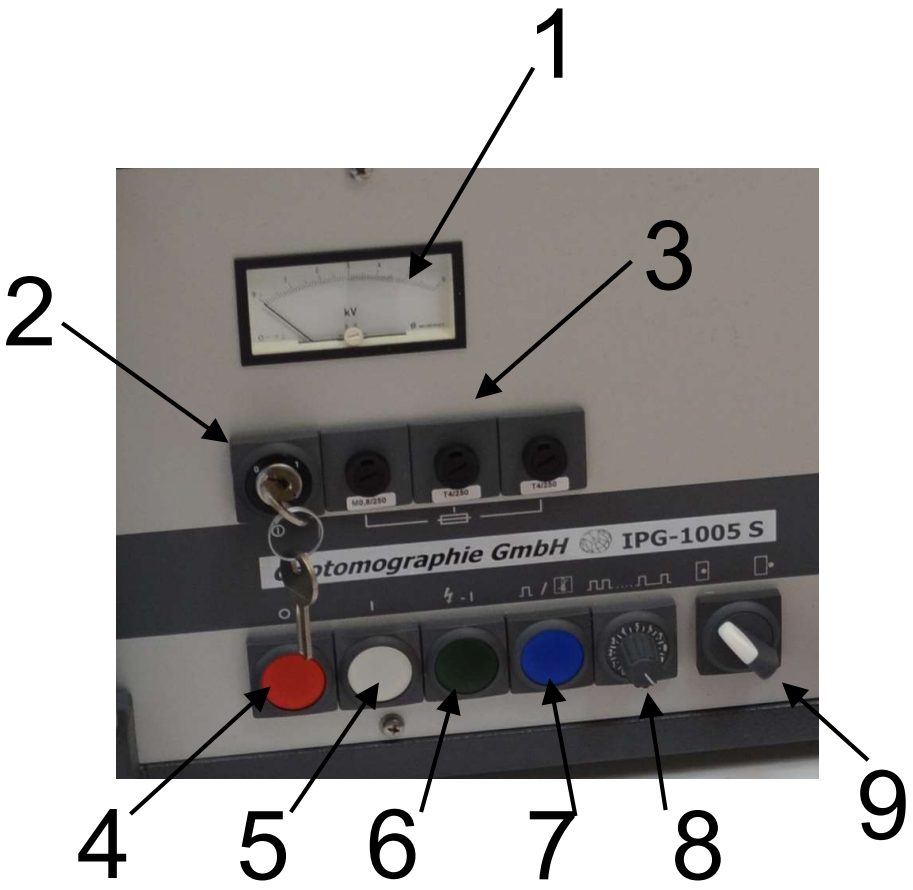


Figure 5: IPG5000 control panel

The front panel of the IPG5000 has a number of controls and buttons (see Figure 5).

1. Voltmeter
2. Key switch (0=OFF, 1=ON)
3. Fuses (from left to right with 0.8 A, 4 A, 4 A)
4. EMERGENCY Stop OFF
5. Voltage (230V) switch ON
6. High-Voltage switch ON
7. Single release button (only available for internal operation)
8. Shot sequence timer (all the way to the left for single shots, all the way to the right for 10 s shot release, all other positions for intermediate shot timing)
9. INTERNAL/EXTERNAL switch (Fully left = INTERNAL, fully right = EXTERNAL for remote unit controlled operation)

In an emergency, switch OFF the IPG5000 using the key switch (2) or press the red push button (4).

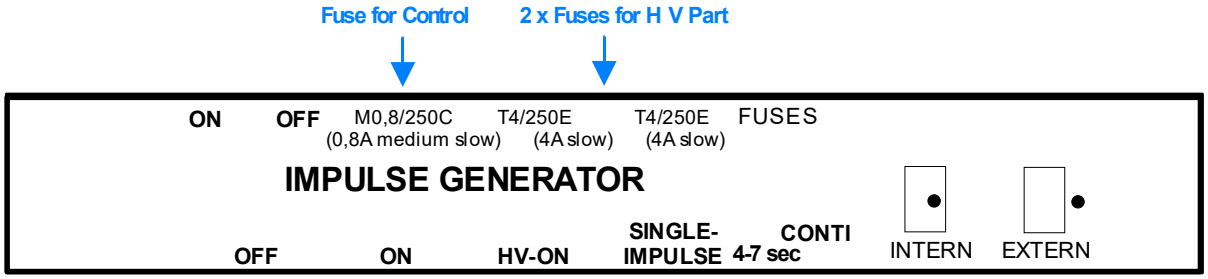


Figure 6: Schematic diagram of the control panel at IPG5000

When all connections to the IPG5000 are made, the remote control unit is connected AND the source inside the borehole & connected, the high-voltage charging can be started.

The switching ON sequence on the IPG5000 control panel using the remote control unit is as follows:

1	Key switch (2) to "1" (same on remote control unit)	
2	Set the shot control at the remote control to SINGLE and to EXTERN at the IPG5000.	
3	If external VAC is present, the white push button (5) will light up	
4	Press the white push-button (5)	
5	The green push button (6) lights up	
6	Press the push-button (6)	
7	High voltage charging starts	

Avoid charging above 5300 V. If charging exceeds this, switch OFF and adjust VAC supply.

Connection to one of the borehole probes is via the “quick” connector on the large red HV cable. Simply insert the probe's coaxial cable connector and screw it tight.

Figure 7: Connection between coaxial cable and large red HV cable on IPG5000

2. Remote control unit (RCU)

The remote control unit has the following functions:

1. Switch ON/OFF the IPG5000
2. Emergency OFF for stopping any operation
3. Shot release in SINGLE or CONTINUOUS mode
4. Impulse count of shots fired
5. Output of trigger signal to the seismograph

The remote control unit is connected to the IPG5000 by a cable. All the electronic circuits of the remote control unit (except the trigger circuit) are powered by the 24 V supplied by the impulse generator via the cable.

The trigger circuit is powered by a 9 V battery.

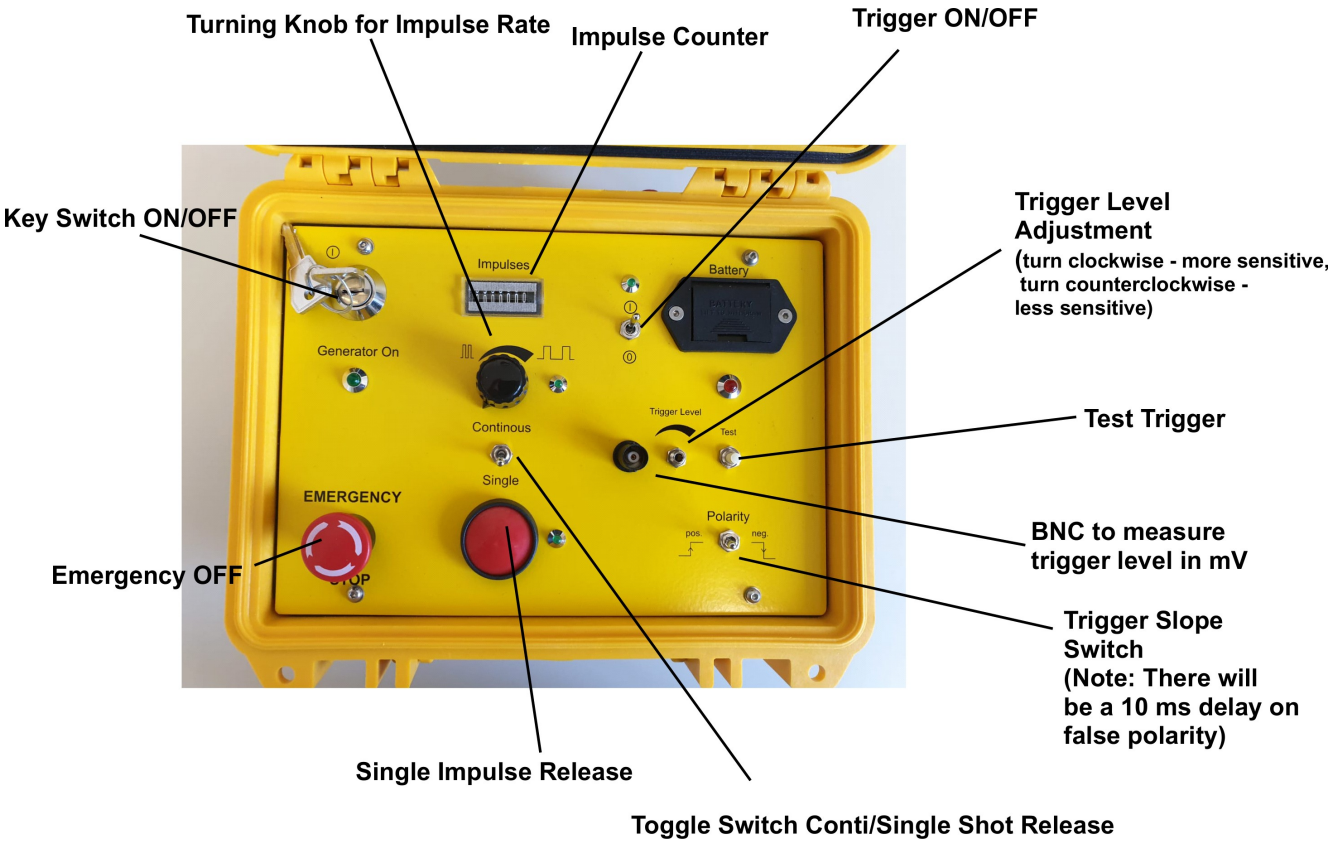


Figure 8: Controls at remote control unit

Figure 9: Rear site of RCU with banana trigger and connector to IPG5000

2.1 Remote control function and operation

To use the remote control mode, the switch on the IPG5000 must be in the EXTERN position. The remote control is divided into three panels.

2.1.1 Generator control (left panel on the remote unit)

The key switch on the remote control unit must be set to “1” to start operation on the IPG5000. The EMERGENCY button must also be in the UP position.

In an emergency, press the “EMERGENCY OFF” button or set the key switch to “0”.

2.1.2 Impulse control (middle panel on the remote unit)

The remote control unit has an impulse counter used for continuous and one-shot firing. Shots can be released in continuous or single mode.

Single mode:
To fire a single shot, switch to “Single” mode and press the **red** button shortly.
The red LED (on right panel of the control unit) will light up briefly.

Continuous mode:
To start continuous impulse operation, switch to "Continuous". You can select faster or longer pulse rates by turning the knob. After a few seconds delay, the first impulse (shot) is released if "Continuous" has been selected. The controller can choose the impulse rate between approx. 4 and approx. 9 seconds and is equipped with a counter for counting the impulses. Continuous shooting can be stopped by switching to SINGLE.

2.1.3 Trigger (right panel at the remote unit)

Turn the toggle switch ON for trigger operation. A red LED indicates that the trigger circuit is ON.

The Trigger LEVEL trimmer can be used to adjust the level of the pulse reference signal transmitted by the pulse generator. Turn clockwise to make the trigger more sensitive and counter-clockwise to make the trigger less sensitive. The level is already set. It should only be readjusted by experienced users.

Since June 2016, there is a BNC socket where the trigger level can be measured with a voltmeter. A trigger level of **50 mV** must be set by adjusting the trigger trimmer to operate the SBS42 and BIS-SH. For operating the BIS-SV set the level to **20 mV**.

To test the correct triggering of the seismograph, the "Test" button can be pressed.

The polarity of the trigger impulse can be selected as positive or negative. The polarity setting affects the trigger output. If a seismic recorder requires a short-circuit for triggering, select down slope (from high to low).

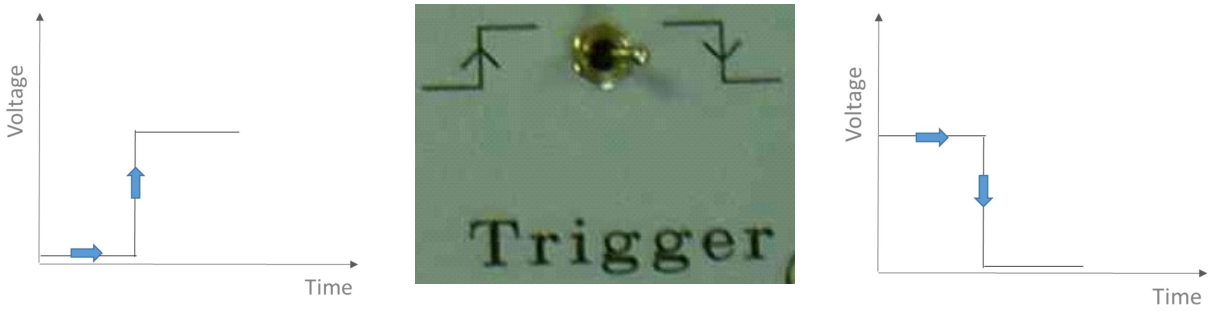


Figure 10: Trigger polarity (TTL Active Low = right switch position, TTL Active High = left switch position)

3. Borehole Sources

The IPG5000 outputs its energy to the SBS42 (P-wave), BIS-SH (SH-wave), and BIS-SV (SV- wave) borehole sources.

The borehole source (SBS42) generates compression waves (P) in water-filled boreholes. The energy released by the IPG5000 is discharged through a coaxial cable terminated by two adjacent spark electrodes placed in a water-filled chamber. The spark discharge vaporises the water by high pressure plasma. This creates vapour bubbles that expand and collapse, generating high-frequency seismic waves.

The BIS-SH borehole source generates horizontally polarised shear waves (SH) and compressional waves (P). The source operates in dry or water-filled boreholes and can be used in vertical or horizontal boreholes. The energy released by the IPG5000 is discharged through a system of electromagnetic coils adjacent to a copper plate. The rejection of the plate creates a mechanical shock to the borehole wall. The borehole source is coupled to the borehole wall by a pneumatic clamping system (inflatable bladder). The orientation of the source is controlled from the surface by a torsionally stiff hose.

BIS-SV's borehole source generates vertically polarized shear waves (SV) in dry or water-filled boreholes. The BIS-SV source can be used with the impulse generators IPG800 or IPG5000. A pneumatic clamping system (inflatable bladder) ensures the coupling to the borehole wall. The source is designed for seismic cross-hole applications. No special alignment of the source is required in the borehole. A switch box is provided to select one of the two SV shot directions „UP“ and „Down“ which improves the practicability of the S-wave source.

3.1 P-Wave probe SBS42 (Sparker)

The borehole sparker probe SBS42 consists of the probe head, an exchangeable spark electrode and the housing (see Figure 11).

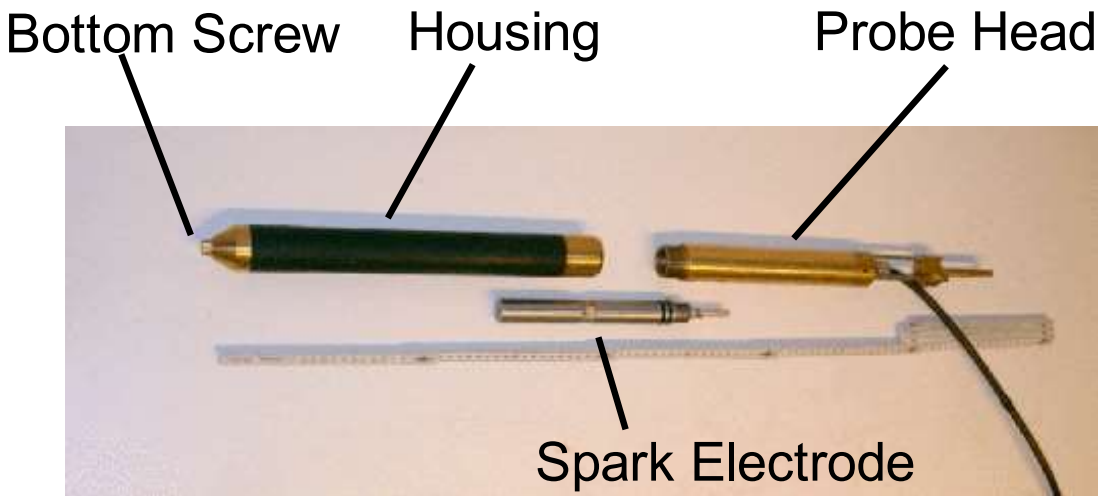


Figure 11: SBS42 borehole source

The probe head electrically connects the probe to the coaxial HV cable. The replaceable electrode is a high-performance long-life stainless steel spark electrode with a tungsten copper alloy inner electrode. The housing consists of a plastic tube with rubber protection around the circumference. Openings made in the plastic tube allow an omnidirectional pressure release into the rock formation. A bottom screw seals the lower end.

The housing can be filled with water through the lower bottom screw thread. Simply remove the screw and fill with water. You can add some salt to the water to increase electrical conductivity (1/2 tablespoon per 500ml of water). Close the bottom screw. If the conductivity of the water is low enough to cause a spark, you can remove the bottom screw and lower the probe below the water level. After a few seconds, the housing will fill with water.

A small amount of gas produced by the electrolysis effect of the current pulses passes through narrow channels and can escape from the probe through openings in the probe head.

The spark electrode is designed for long-term operation and has a whole life of several thousand shots. It is recommended that the front face of the electrode be flattened with a mechanical filing tool after approximately 1000 to 2000 shots.

When replacing the electrode, ensure that the system is switched off. Hold the electrode downwards to prevent water from entering the probe head when replacing it. Apply grease only to the O-rings.

Only grease the spark electrode O-rings. **Do not grease the spark electrode threads**.

Do not fire into free air if the sparker probe is filled with water. The rubber hose may be overstretched due to a lack of static counter pressure. For this reason, the minimum operating depth should not be less than approximately one metre below the water table.

The rubber hose section can be dismantled for repair or maintenance, e.g., the spark electrode.

3.2 S-Wave probe BIS-SH

The borehole source BIS-SH generates horizontally polarised S-waves in a borehole. Based on an outer diameter of approximately 65 mm, the BIS-SH probe can be used for SH-wave surveys in boreholes with a minimum diameter of 75 mm and up to 4 inches without extension.
The BIS probe consists of the probe head, two half sleeves, the rubber-protected and sealed active probe part, an air packer, and the lower probe part (see Figure 12).

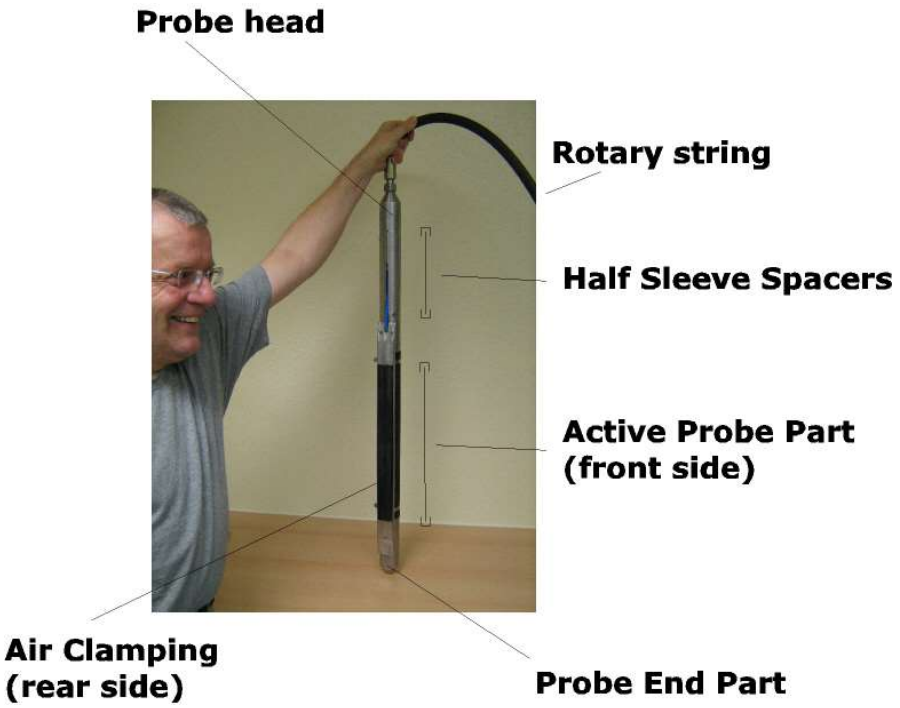


Figure 12: BIS-SH probe

The probe head is connected to the rotary pipe string. This connection should always be checked for tightness. The rotary pipe string has three functions, i.e., (1) to protect the inner coaxial cable, (2) to orientate the source and (3) to direct air to the packer.

The two half sleeves connect the probe head to the active part of the probe. One side can be opened for operation to maintain the cable connection (cleaning) and to connect/disconnect the air hose (see Figure 13).
The active part of the source contains an eddy current seismic source. A heavy-duty rubber tube (3 mm wall thickness) protects the HV part from water and dust.

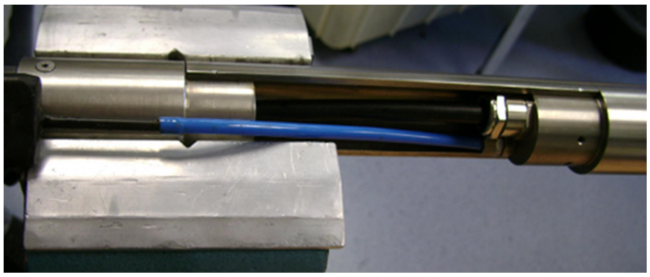


Figure 13: Half-Sleeves with HV cable and pressure hose connector

The active part of the probe (firing direction) must be aligned with the rotary string mark (see Figure 14).

Figure 14: Rotary string alignment (points towards shooting direction)

Figure 15: Rotary string depth markers

The air clamp can be easily removed by unscrewing it from the active part.

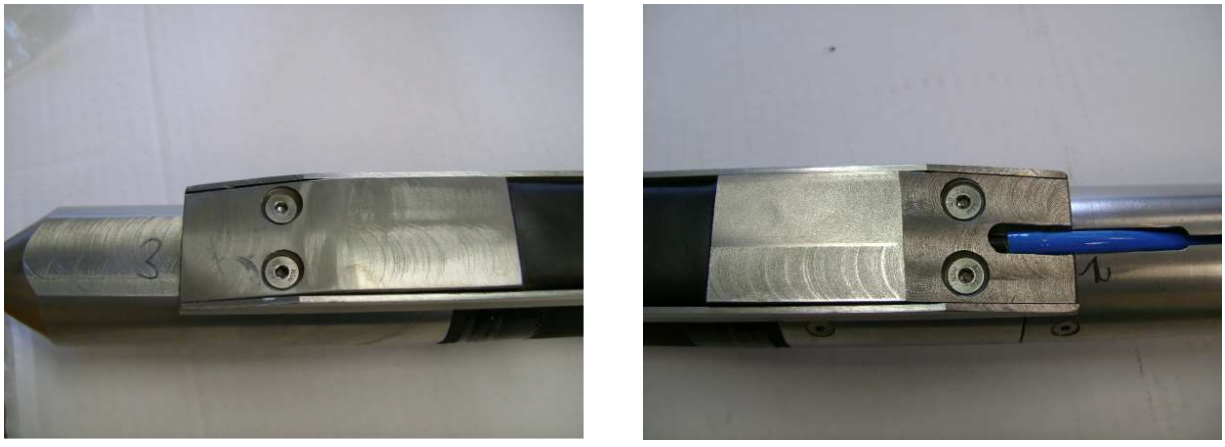
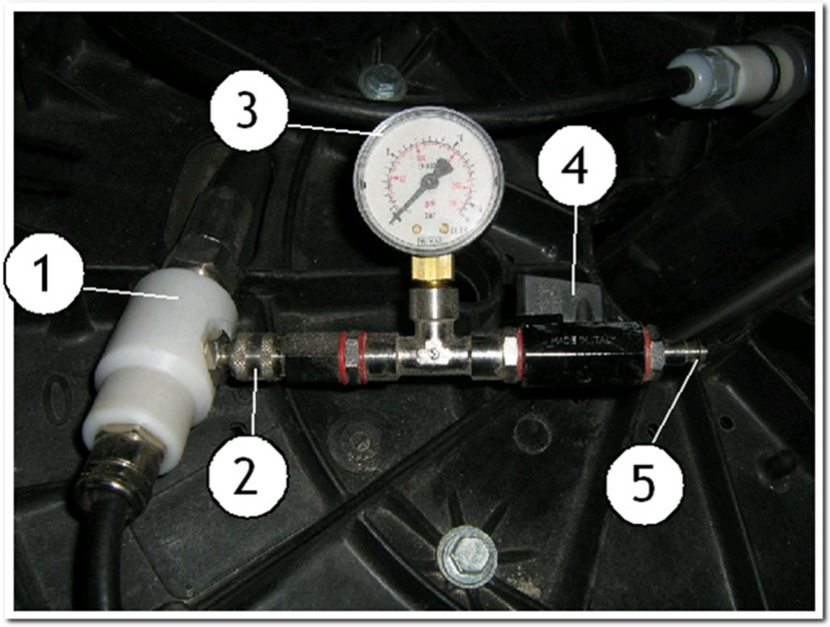


Figure 16: Unscrew to replace air bladder

The BIS-SH probe can operate in both water-filled and dry boreholes.

However, when operating in dry boreholes, the internal temperature of the coil system rises rapidly (up to 100°C). Ensure there is no overheating (e.g., after 30...50 shots in continuous operation without stopping). In normal/regular operation (5 stacks per direction), no overheating should occur.

Check the rubber tube on the active part of the probe regularly. If the rubber is damaged, water may enter the coil system. This will cause a short circuit in the coil system and result in total damage to the inner coil system.



1 : Splitter
2 : Push-Pull connector on valve-gauge adapter
3 : Pressure gauge
4 : Valve
5 : Connector to air pump

Figure 17: BIS-SH surface splitter arrangement

The borehole rotary string ends in a white plastic cylinder, usually mounted directly on the reel (see Figure 17). This end termination separates the HV cable and the air connection (for inflating the BIS-SH packer).

A special gauge-valve adapter can be connected to the air inlet. It is a push-pull connection on the gauge-to-valve adapter. An air pump is provided to inflate the packer to clamp the source to the borehole wall. Again, please be aware of the **push-pull connection**.

Once air pressure is applied to inflate the packer, close the valve and disconnect the air pump. No air can be released without disconnection. **Always keep the push-pull connections clean!**

3.4 S-Wave probe BIS-SV

The borehole source BIS-SV generates vertically polarized S-waves in a borehole. Based on an outer diameter of about 65 mm, the probe BIS-SV can be used for SV-wave cross-hole surveys. Coupling to the borehole wall is through an inflatable air packer. It's the same packer and clamping mechanism used for the BIS-SH source.

Figure 18: BIS-SV borehole source

The borehole source consists of the following parts:

1. BIS-SV with cable and markings on drum, standard length 50 m
2. Valve and gauge adapter
3. Spooler and air pump
4. HV relay switch and remote switch box (up/down)

Figure 19: BIS-SV source

Functions:

(1) : BIS-SV probe with outer friction enhancer material
(2) : HV connector to IPG5000
(3) : Air packer
(4) : Remote switch box for Up- or Down shots
(5) : HV relay switch box
(6) : Air connection

A high voltage relay switch box is mounted on top of the cable drum. Inside is a relay that allows the up or down strike to be switched. The relay requires a 24V supply, which is provided by a cable connection between the relay box and the RCU (socket at the rear of the RCU).

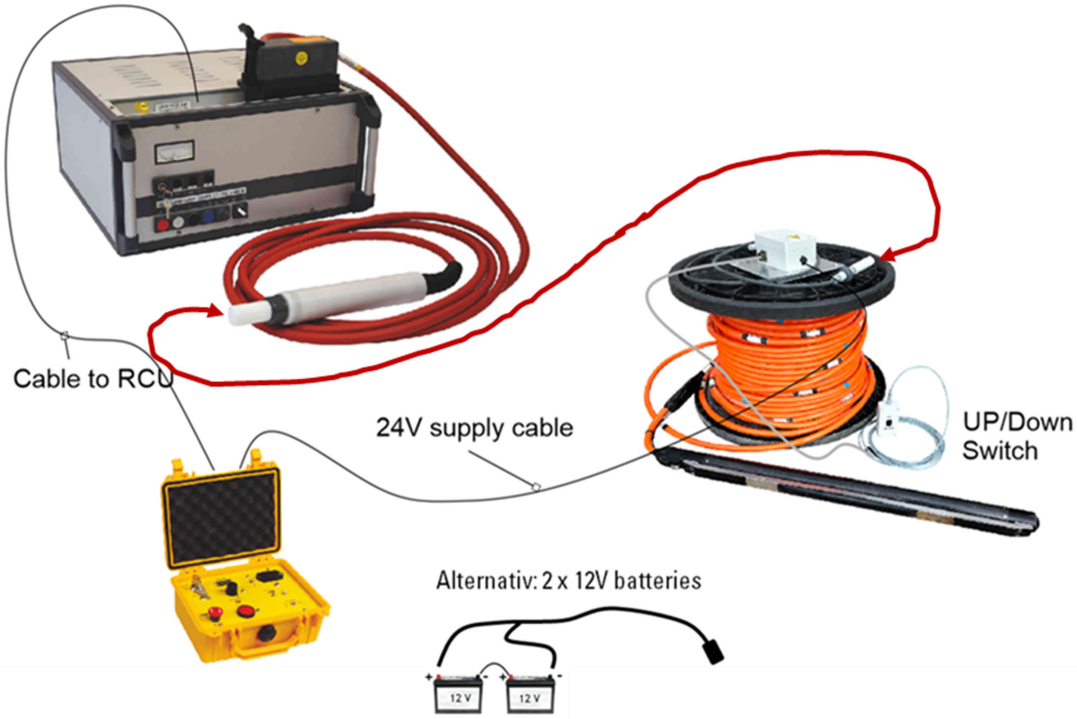


Figure 20: Schematic connection diagram

The HV relay box (see figure 19, function 5) is mounted on top of the cable drum. It has three connections, i.e. the 24V power in, the connector socket to the UP/Down switch box and the air in supply (see below).

Figure 21: UP/Down remote switch box with connections

A remote switch box allows up/down switching (see Figure 19). The box needs to be connected to the HV relay box on top of the cable drum.

Under no circumstances - do not switch while a shot is being released.

For example, you can do five shots in Up direction, then stop, switch to Down and continue with five shots in the Down direction. If the data quality is poor, you can set a higher gain factor on your seismograph.

There is a friction-enhancing material glued to the outer housing (see Figure 22). This aims to increase friction and reduce the sliding of the source along the borehole wall during shooting.

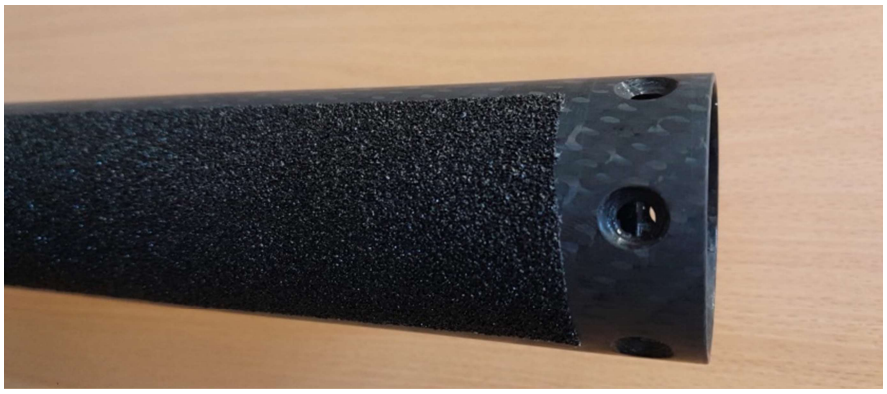


Figure 22: Friction-enhancing material covers the outer probe housing

The active part of the source contains a seismic source working after the eddy current principle. A high-duty rubber tube (3 mm wall thickness) protects the HV part from water and dust.

The probe works in water-filled or dry boreholes!

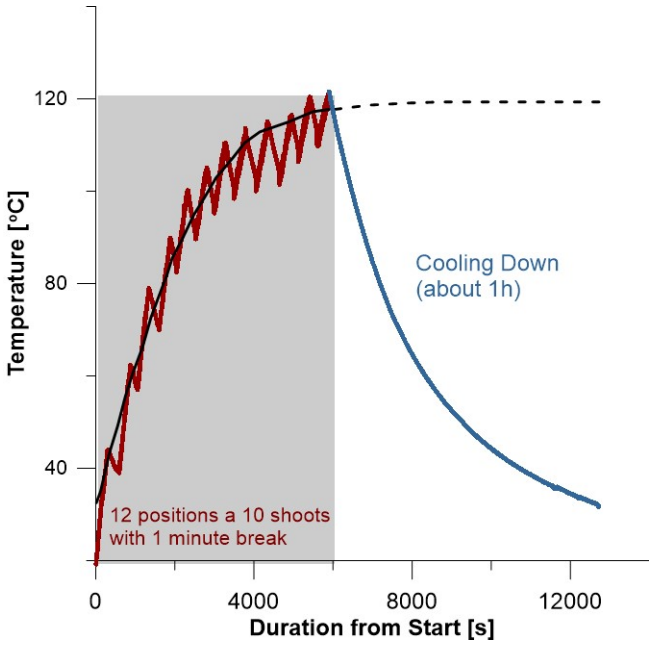


Figure 23: Temperature behaviour

Due to the high energy, the active probe part heats up quickly. The temperature rises quickly up to 120°C. Take care not to overheat. A maximum of 5 shots in one direction is recommended. This is mainly observed in dry boreholes where cooling is not optimal compared to water-filled boreholes.

4. Operation and maintenance instructions

4.1 Impulse generator and remote control unit (surface equipment)

4.1.1 Preliminary works

→ Plant earth hook to ground. If the ground is dry, pour some water around the spike to improve conductivity. Connect the earth hook with green/yellow cable to the ground of the impulse generators (rear side).

→ Make all cable connections for surface and subsurface equipment according to the instructions!

→ Connect the AC power cable (but do not switch on the AC generator until all preparation work has been completed).

→ Put borehole probe into the borehole and fix with clamping device.

4.1.2 Impulse operation control (EXTERNAL) - controlled by remote unit

1	Key switch at remote control unit to “1” and emergency button is UP	
2	Set toggle switch at remote control unit to SINGLE	
3	Switch trigger on at remote control unit and set trigger type (low or high depending on seismograph)	
4	Connect the impulse generator to mains or other AC-current source	
5	White lamp lights and indicates readiness for switching on the IPG5000	
6	Switch to EXTERNAL ( ) at IPG5000	
7	Set the key switch at IPG5000 to “1”	

8	Press the white push-button (green lamp lights).	
9	Press the green push-button at IPG5000 Now, the high voltage circuit is switched-on internally, and charging of the condenser bank is started (see voltage meter for increasing voltage). The Impulse generator is ready for impulse operation by remote unit control. The system is ready to work @ 5KV.	
10	If the **SINGLE shot** release is set at the remote unit press red button at middle remote unit panel to release single shots.	
11	If the **CONTINUOUS shot** release is set at the remote unit shots are automatically released. You may set repetition rate at turning knob.	
12	Stop continuous shooting by switching to SINGLE.	

4.1.3 Impulse operation control INTERNAL

When using the generator without operation from the remote control, the following steps have to be carried out:

- Follow the steps described under 4.1.1
- Connect the blind plug to IPG800 instead of the remote control cable
- The trigger signal can be obtained from the BNC connector located at the rear side of IPG5000 (available since June 2016)
- Shot sequence timer at impulse generator for select shot cycle rate fully left!
- Switch the toggle switch at the impulse generator to INTERNAL ()
- Switch the key switch at IPG5000 to "1"
- Press the white push-button ON at IPG5000
- Press the green push-button HV-ON (impulse generator charges now)
- You may release a single shot by pressing the blue push-button shortly!!!

Note: As long as you press the blue button impulse generator discharges via downhole cable! Danger, do not touch any parts of the downhole probe or electrically connected parts to it.

- Alternatively, you may release continuous shots by selecting an impulse rate at the shot sequence timer
- For shut down press red button OFF or use key switch.

4.1.3 Setting OFF operation

Turn the key switch at the remote control unit to position “0”.	

- Alternatively and equivalent

press the red button at the impulse generator	
press the emergency button at the remote control unit	
switch the key at IPG5000 to position “0”	

4.2 SBS42 probe (Sparker)

- Ensure the probe is disconnected from the IPG5000 before carrying out any maintenance.
- If the housing rubber tube is damaged, the electrode spark function will not be affected under normal conductivity conditions of the borehole fluid (water). In any case, the rubber hose can be easily replaced.
- Do not use the probe without the housing.
- It is recommended to flatten the front electrode surface with a mechanical filing tool after approximately 1000 to 2000 shots.
- Check the coaxial cable for damage, i.e., breaks and cuts. Do not pull the cable over sharp edges. Do not drive over or step on the cable.
- To temporarily repair such cable damage, wrap some self-vulcanising tape or insulating tape around the damaged area to prevent water penetration.
- Use a multimeter to check cable insulation.

4.2.1 Checking the Sparker Electrode

A sparker electrode needs to be screwed inside the SBS42 probe. System power has to be OFF and the system has to be completely discharged.

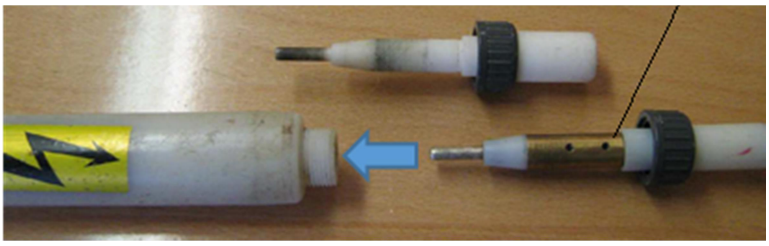


Figure 24: Screwing sparker electrode inside the SBS42

Each sparker electrode starts with a new and flat surface. The recommended sparker electrode gap is 5 mm between the inner and outer ring electrodes.

Figure 25: (left): new and flat surface of the sparker electrode; (right): sparker electrode (with groove)

Figure 26: Sparker electrode screwed in completely

Screw in the electrode till the groove at the electrode is aligned with the outer thread for the sparker chamber.

The sparker electrode undergoes abrasion on continuous use. It is still working, but will show further wear if the electrode is not flattened at the end of the day.

To flatten the electrode use a file or a saw. Remove the burrs from the electrode. Electrodes that show heavy abrasion break down sooner or later and lead to unstable signal quality and unstable triggering.

Figure 27: (left): new and flat surface of the sparker electrode; (right): sparker electrode after about 2000 shots

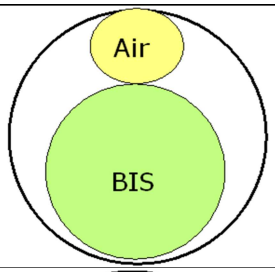
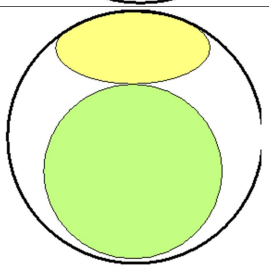
4.3 BIS-SH/BIS-SV probe

- Before starting any maintenance, ensure that the probe is disconnected from the IPG5000.
- Check the rubber hose for damage.
- Do not use a damaged rubber hose.
- Avoid long/extensive shots in dry boreholes as the probe may heat up quickly.

4.3.1 Clamping pressure for BIS-SH/BIS-SV probe

The BIS-SH source must be properly clamped to the borehole wall to produce good S-wave data quality.

Please follow the suggested procedure:

1.	Insert the source into the boreholes only about **half a metre** and secure it to the surface.	
2.	Pump air into the source and stop when the bladder reaches the housing. Check the pressure (A).	A) 
3.	Add about **0.8 to 1 bar** more for full clamp (B). Remember this pressure. This is the clamping pressure in the borehole under atmospheric conditions. Below the water table, you will need to add hydrostatic pressure **(1 bar = 10 m)**.	B) 

Example:

(1) Water table at **5m**
(2) Clamping pressure at surface measured with **1.6 bar**
(3) BIS-SH at 20 m depth (20m - 5m = 15 m → equal to **1.5 bar** water pressure with 1 bar = 10m)
(4) Clamping pressure at 20 m is **1.6 + 1.5 = 3.1 bar**

4.3.2 Orienting the BIS-SH probe

The BIS-SH generates SH waves. These waves have a particle motion perpendicular to the propagation direction. The propagation direction is assumed to be the line direction from borehole to borehole. Therefore, the source impact direction must be perpendicular to it (see Figure 25).

The rotary pipe string is used to orient the source. It is recommended to align the marking of the pipe string -/+ 90° to the line direction between boreholes.

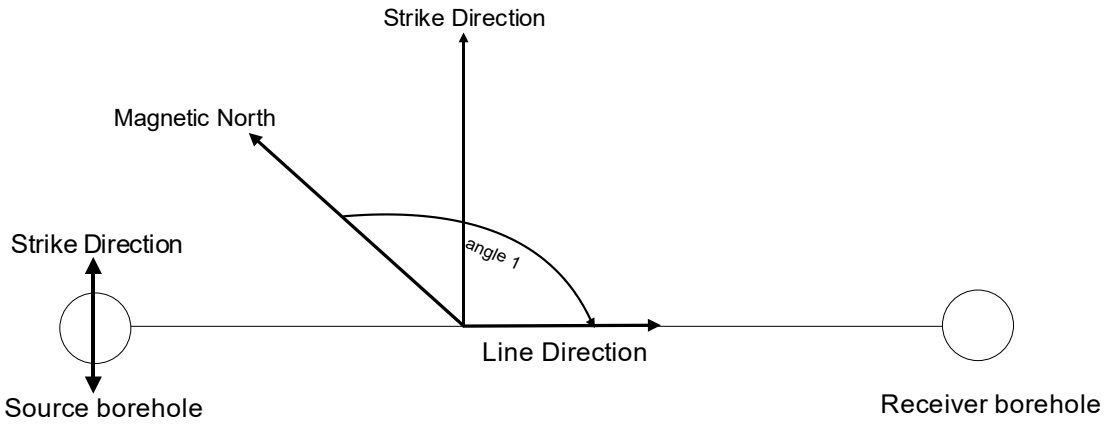


Figure 28: Orienting the BIS-SH

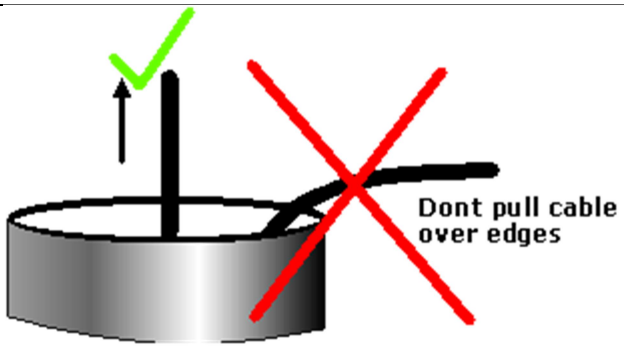
Once the rotary pipe string is rotated, clamp the string using a workbench (see Figure 30).

Figure 29: Fixation of the BIS-SH using the workbench

4.4 Surface cable and quick connector

- Keep connectors away from dust, moisture and water.
- Do not bend the cable excessively.
- After disconnecting, insert the plastic sealing plug into the quick connector.

4.4.1 Cable handling

1	Avoid pulling the cable over **sharp edges**.	
2	Avoid **loops or kinks** when winding or pulling the cable along the surface. This will result in damage to the cable jacket and water may migrate into the cable and damage the probe.	

5. Set-up for different seismic measurements

5.1 Tomography arrangement

Seismic tomography provides high-resolution 2D or 3D images of seismic velocities between boreholes. The method is used to delineate geological structures, to map cavities and weak zones, and to specify mechanical soil and rock properties. Geophysicists and engineers apply this method to investigate the foundation and underlying rock of buildings and bridges to characterize the subsurface before infrastructure is built and to image time-dependent processes.

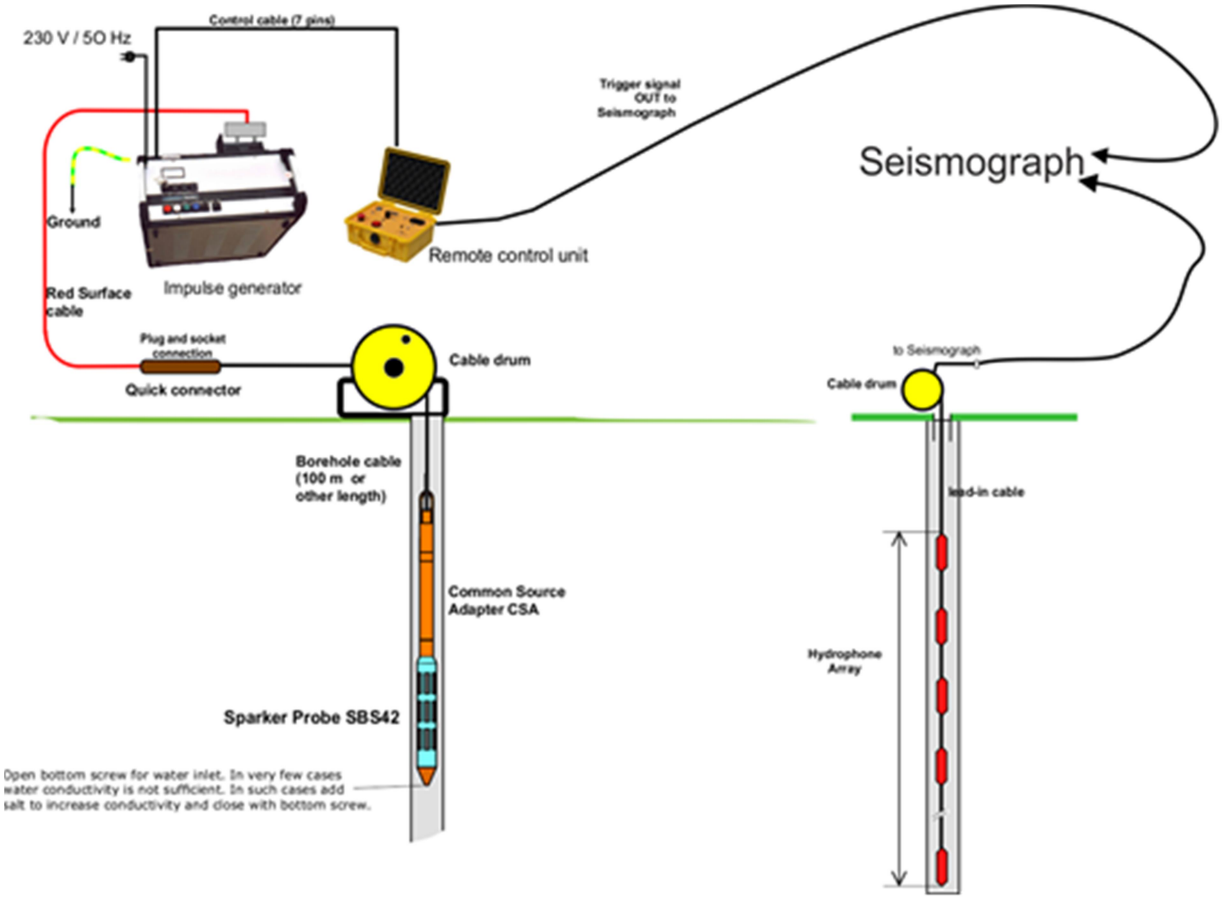


Figure 30: Set up for tomographic measurements

5.2 Crosshole arrangement

The crosshole test provides a depth profile of shear wave velocities (VS) and compressional wave velocities (VP) between boreholes at a high vertical resolution. The method is used to determine soil dynamic parameters, such as shear modulus, Poisson ratio and Young's modulus. Engineers use these key parameters to predict the response of soils to dynamic loading.

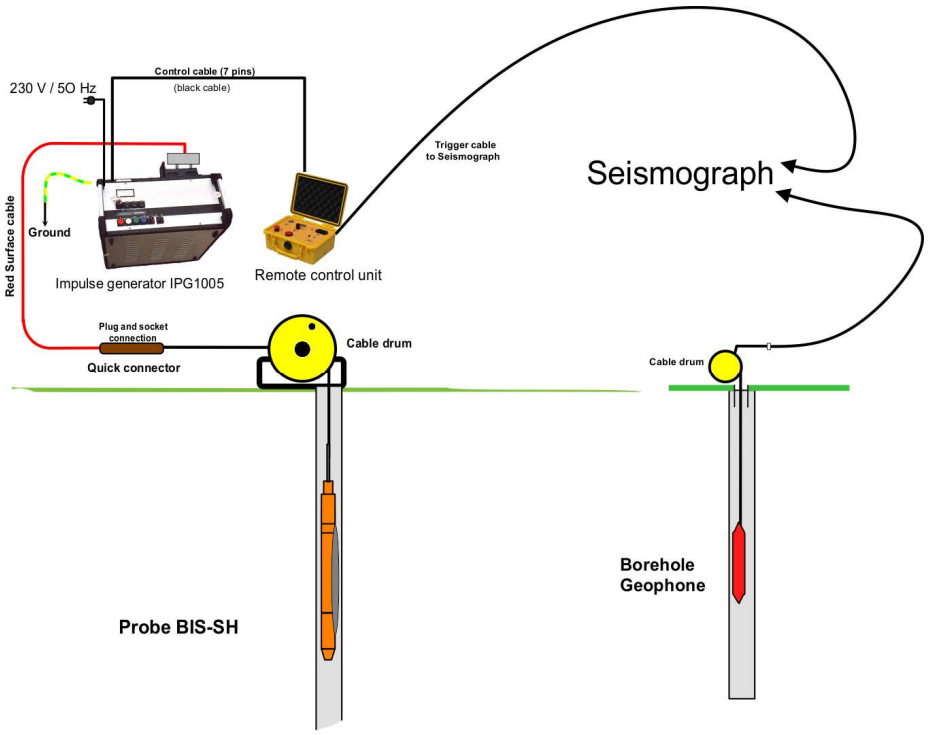


Figure 31: Set up for cross-hole measurements

6. Trouble shooting

If at any time function at remote unit or impulse generator do not work switch off system and disconnect from AC power.

5.1 Check triggering

- Switch on the trigger on the remote control. The red LED should light up.
- Check that the 9V battery is fresh. A low battery may cause false triggering.
- Connect trigger to seismograph and arm seismograph.
- Press the 'Test' button on the remote control. The red LED should flash. Flashing indicates that a trigger pulse is being sent. In principle, the LED should also flash as soon as a real shot is released.
- If the LED only flashes when the Test button is pressed but does not flash when a shot is fired, you need to adjust the trigger level on the remote control. Use a small screwdriver and turn to a more sensitive level (see Figure 8). Adjust the level while shooting with the SBS42, BIS-SH or BIS-SV.
- If the LED flashes red but no trigger is received from the seismograph, check the trigger cable between the seismograph and the remote control unit (the cable may be broken).
- Last but not least, you can check the output of the banana plugs themselves if a trigger is output.
- **Instruction:** You need a resistor of R=1 kOhm and a red or green LED. Remember that the long leg of the LED is the anode (+).On the remote control the red banana plug is (+) and the black banana plug is (-). The red LED is always easier to see! Release a test trigger and see if the LED flashes or not.

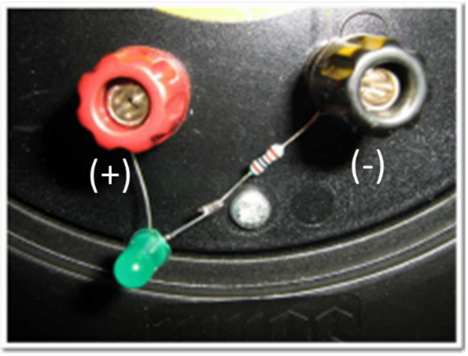


Figure 32:Trigger box connections

When all efforts to get a trigger signal from the remote control have failed, there is one last chance to get a trigger signal. Take a 1m piece of insulated copper wire and wind it 4 - 6 times around the large red HV cable from the IPG5000. Connect both ends to the input of your seismograph. Check if it works. Note that the more turns, the more voltage! Be careful not to damage the trigger input of your seismograph.

5.2. Outdoor Test arrangement

To check that the system is working, a small "**bucket of water**" test can be carried out on the surface (see Figure 32).

Please be careful and stay away while the system is operating.

Do not perform the test indoors as the bucket may break and water will spill out.

You can remove the casing from the SBS42 probe. Be careful not to touch uninsulated parts.

Ensure that the electrode tip is approximately 10 cm above the bottom of the bucket and away from the sides.

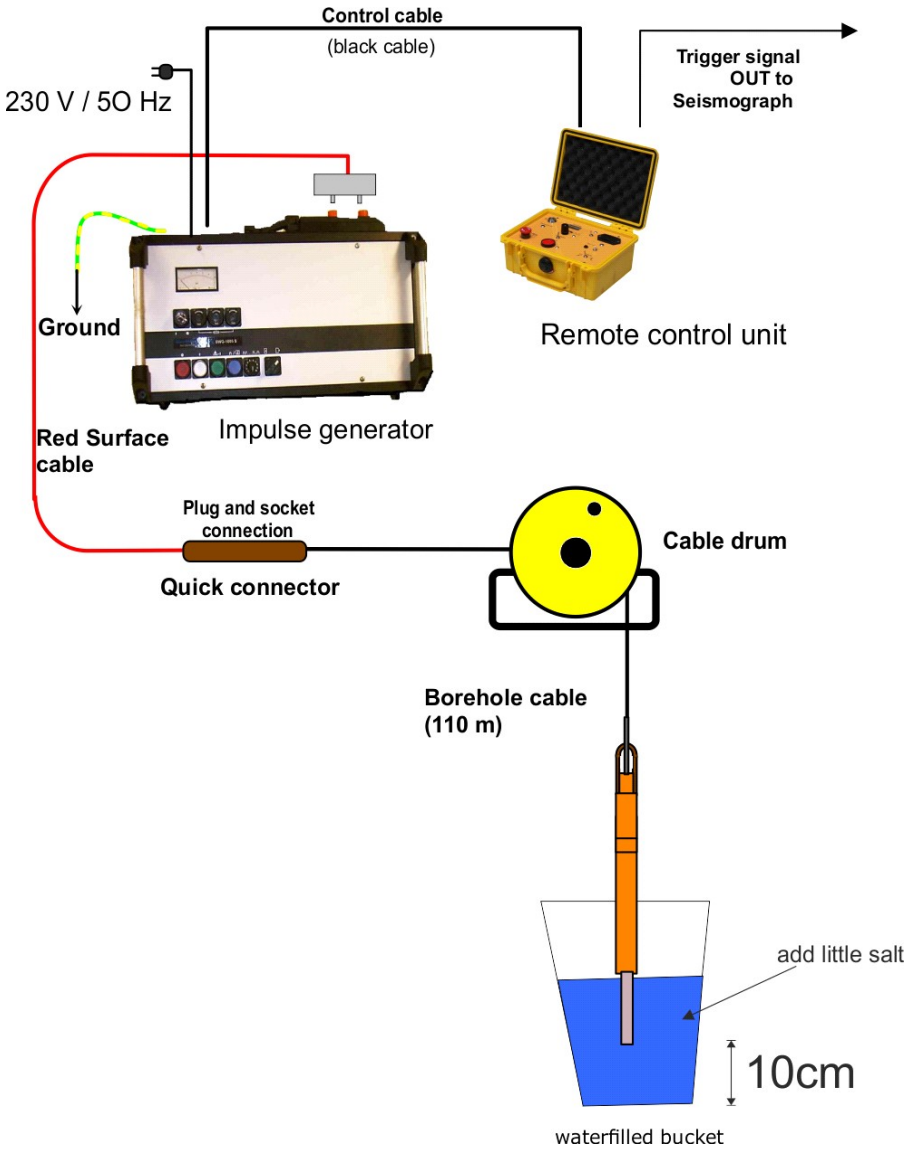
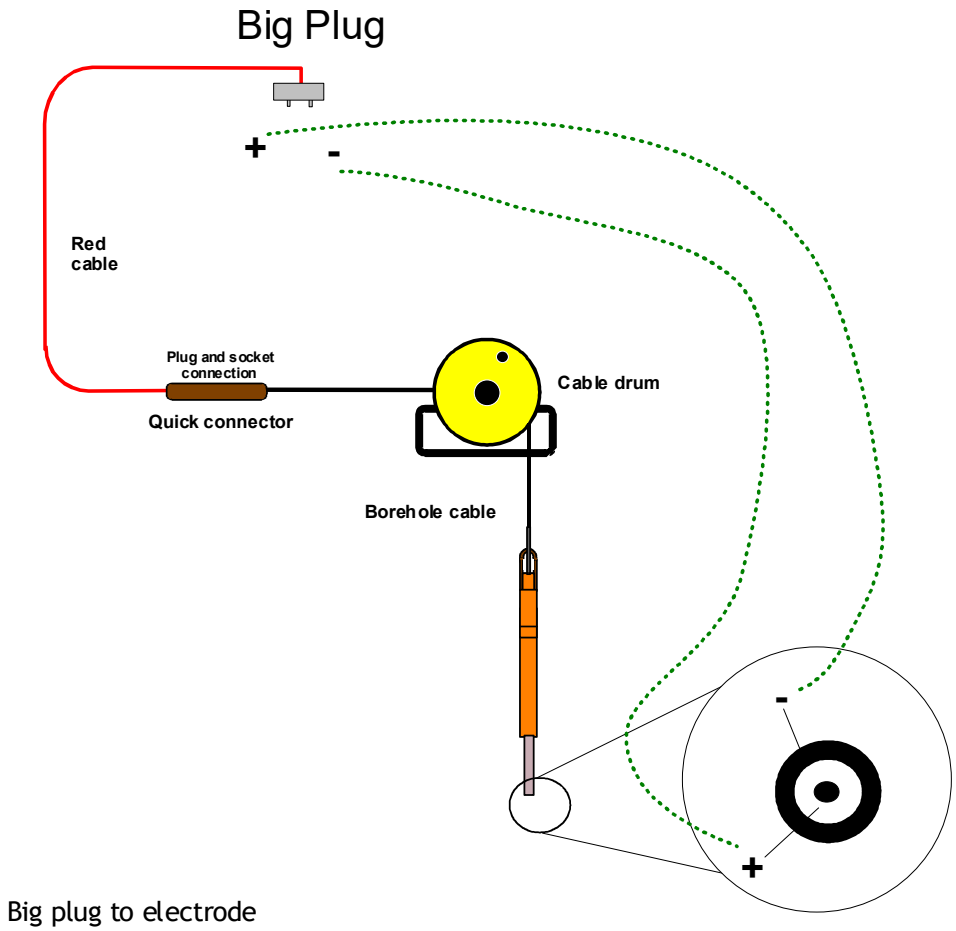


Figure 33: Outside test arrangement with small "bucket of water"

5.3. General Checks

- Check all cable connections to ensure that the pins are in the correct position and that no pins are broken or not of the correct length.
- Check continuity of all cables.
- Avoid pulling the cable over **sharp edges** and **loops or kinks** when winding or pulling the cable along the surface. (see *4.4.1)*



Big plug to electrode
1. Measure continutity between each +/- pole
2. Cross-check with the other pole

Quick connector to Electrode
1. Measure continutity between each +/- pole
2. Cross-check with the other pole

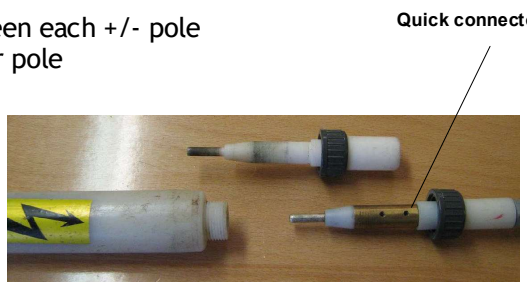


Figure 34: Check continuity for SBS42

5.4 Case 1: IPG5000 does not charge (operated in extern mode)

- Check the VAC supply voltage if perhaps too low.
- Check fuses if OK.
- Key switches all to “1”?
- Is the emergency button UP at the remote control unit?
- Big connector properly fixed with rubber at IPG5000?

1. The green lamp lights continuously.
2. Switch to INTERNAL and try again.
3. Still, NO; disconnect the remote control cable from IPG5000 and connect the blind plug. Try again.

5.5 Case 2: IPG5000 does not discharge

This is a typical case if no spark can happen (for SBS42) because there is a too high resistance.

- Check if all connections are established and OK
- Perform the test described under 5.2 by adding salt to the water
- Check the continuity shown in Figure 34
- Check cable if cutted