SONELASTIC
Advanced Impulse Excitation Technique

Installation and Operation Manual

SA-BC

Adjustable support for bars and cylinders

ATCP Physical Engineering, Sonelastic® Division

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SA-BC

Adjustable support for bars and cylinders

Manufactured by:

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1. Introduction

ATCP Physical Engineering equipment and products were projected and manufactured to provide a long-lasting and top-rated performance. This Installation and Operation Manual contains all necessary information regarding the use and maintenance of SA-BC Support.

Carefully read this manual before using the SA-BC support. Improper use may damage the product and affect its performance.

2. Definitions

Impulse Excitation Technique: The Impulse Excitation Technique is a non-destructive technique to determine the elastic moduli and damping of materials by the resonance frequencies of test specimens. ASTM E1876 is the main standard related to the Impulse Excitation Technique.

Resonance frequencies: Specimen natural frequencies of vibration.

Elastic modulus: Elastic modulus or Young's modulus is defined as the slope of the stress-strain curve at the elastic region, as described by Hooke's Law. The elastic modulus determined by Impulse Excitation Technique is also termed as dynamic elastic modulus.

Damping: Damping is the phenomenon by which mechanical energy is dissipated in vibration systems and elements. It is directly linked to the presence of defects and to the material microstructure.

3. Features and applications

SA-BC Support is an apparatus to support specimens for non-destructive characterization of Young's modulus and damping of materials by Impulse Excitation Technique, in agreement with ASTM E1876 and correlated standards. SA-BC Support was developed to be used alongside Sonelastic® Systems.

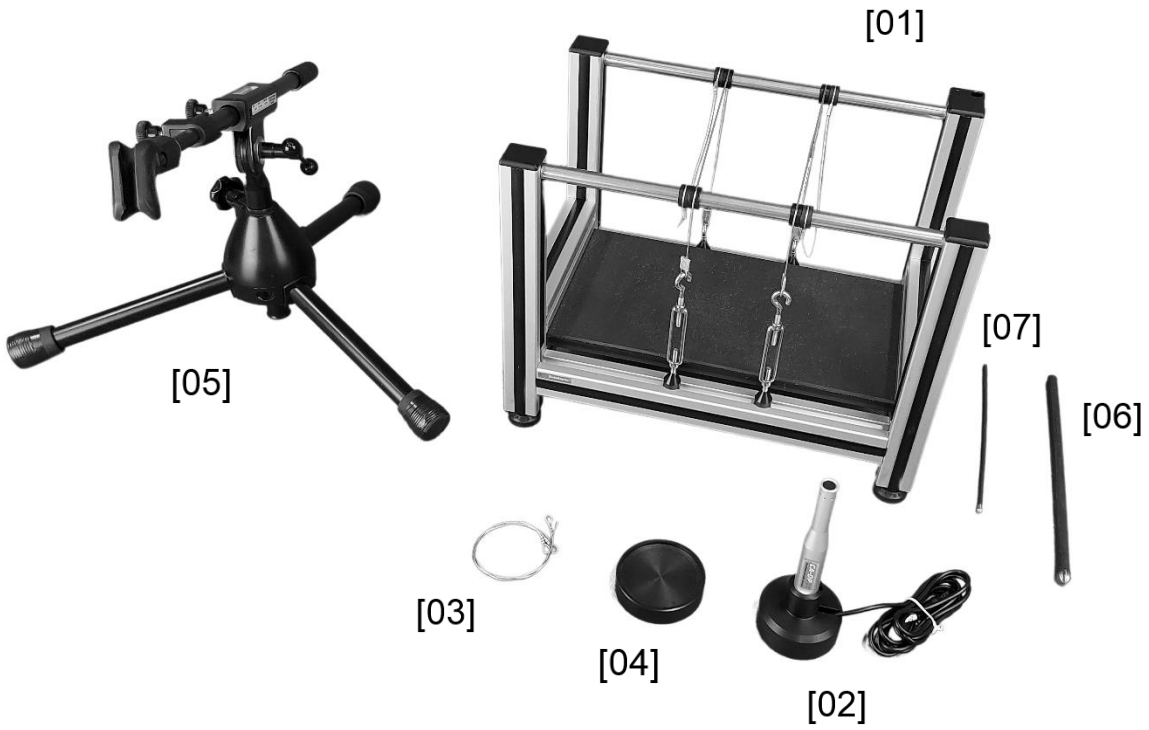
SA-BC Support allows rectangular and cylindrical specimens to rest on the nodal lines of the fundamental flexural vibration mode (for a specimen of length L, these nodal lines are 0.224L distant from the ends). Based on the size and weight of the specimen to be tested, this support offers a practical system to adjust the distance between the support-cables, as well as the traction on them. SA-BC Support also allows tests based on torsional and longitudinal vibration modes for bars and cylinders.

For greater convenience, SA-BC Support may be combined with IED Automatic Impulse Device and Sturdy Tripod.

4. Configurations, parts, accessories and optional items

SA-BC Support is available in both manual and automatic configurations. Optional items are offered to customize the Sonelastic® Systems.

Manual configuration



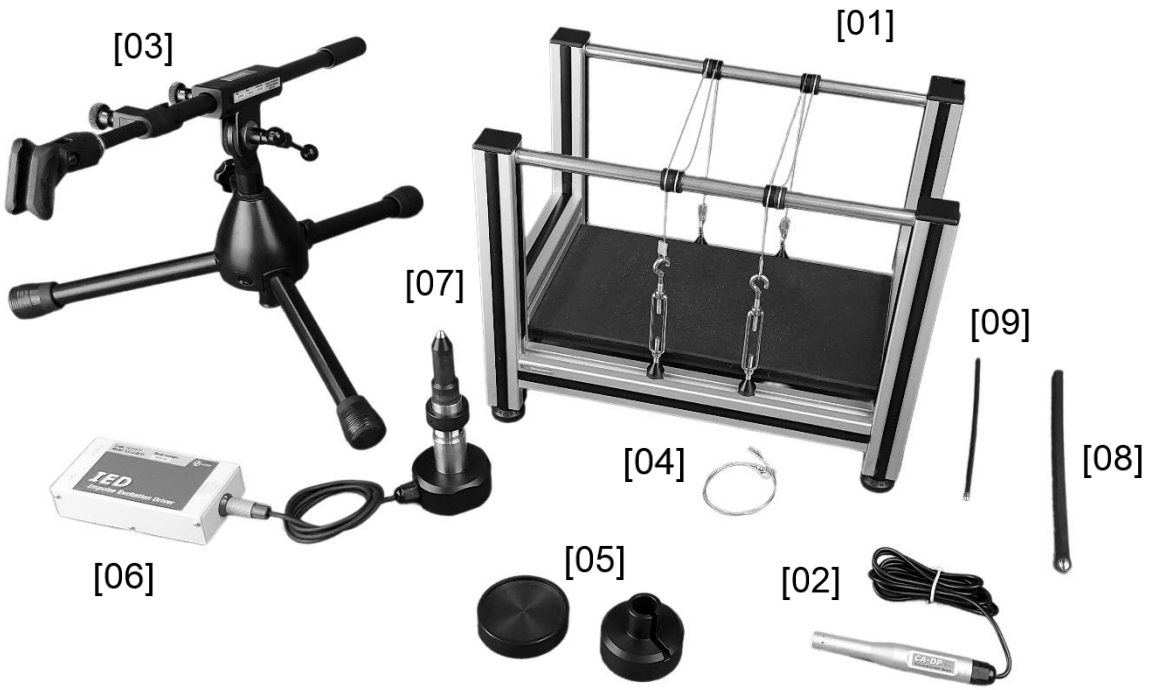
Parts:
[01] – SA-BC Support;
[02] – CA-PD Acoustic Sensor with vertical mounting base.

Accessories:
[03] – Spare support-cable set;
[04] – Height-adjusting disc;
[06] – Medium Manual Impulse Device;
[07] – Light Manual Impulse Device.

Note: The SA-BC Support includes a protective cover which is not shown in the image.

Optional Items:
[05] – Sturdy Tripod.

Automatic configuration



Parts:
[01] – SA-BC Support;
[02] – CA-PD Acoustic Sensor.

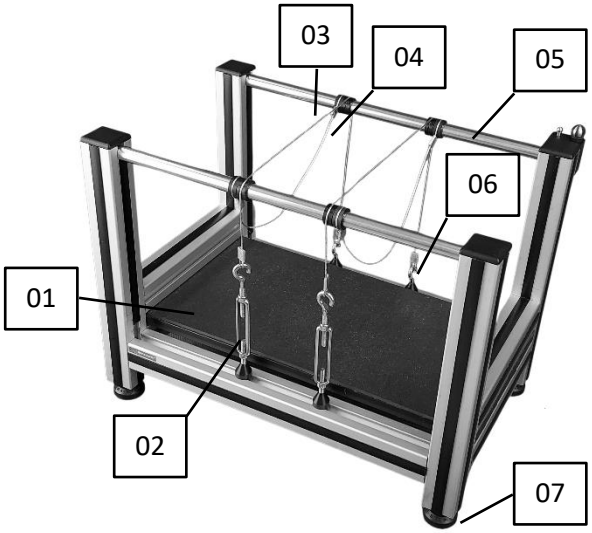
Accessories:
[04] - Spare Support-cable set;
[05] - Height-adjusting disc for the CA-PD Acoustic Sensor;
[06] - IED Automatic Impulse Device control unit;
[07] - Medium RT Impulse Device;
[08] - Medium Manual Impulse Device;
[09] - Light Manual Impulse Device.

Note: The SA-BC Support includes a protective cover which is not shown in the image.

Optional Items:
[03] – Sturdy Tripod.

5. Parts identification

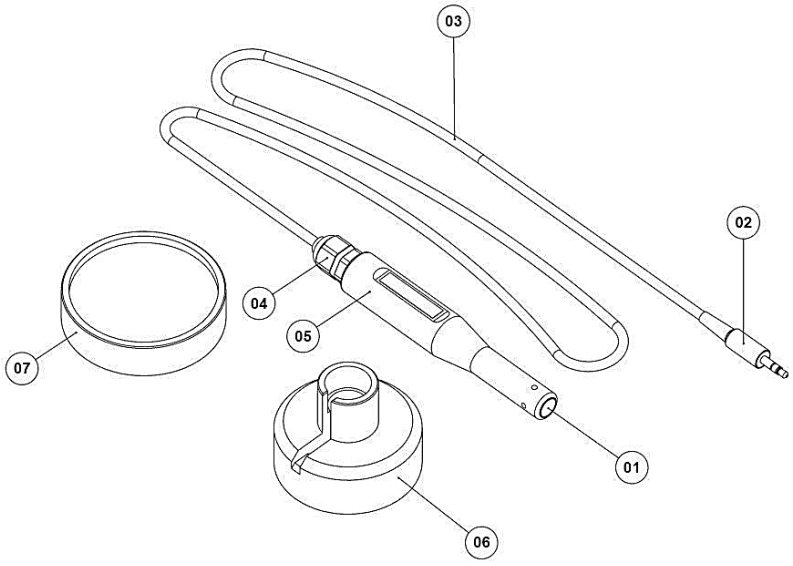
SA-BC Support



01- Support base;
02- Support-cable tightener;
03- Support-cable;
04- Safety cables;
05- Support bar;
06- Anchoring terminal;
07- Leveling foot.

* Two sets of cables are provided: a Ø1.2 mm cable, for heavier specimens, and a Ø0.7mm cable, for lighter specimens.

CA-PD Acoustic Sensor

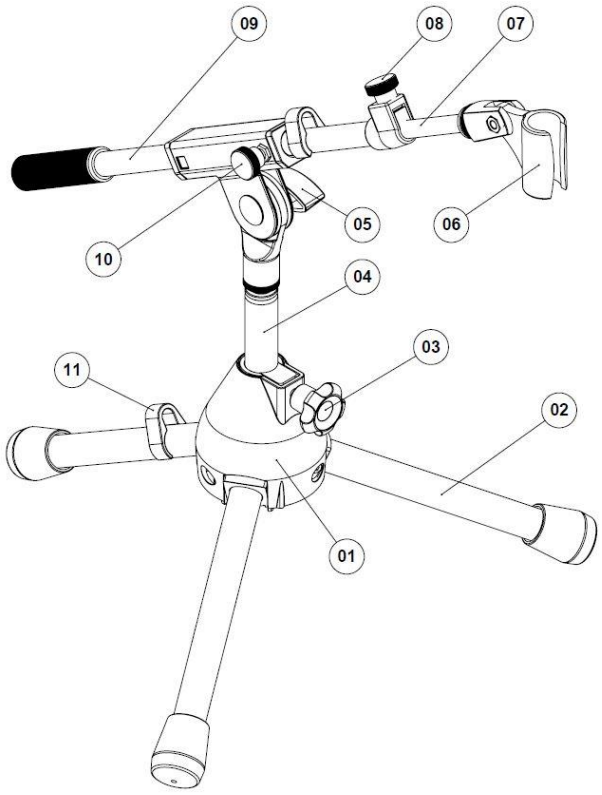


01-CA-DP Acoustic Sensor;
02- P2 plug (3.5 mm);
03- Flexible cable;
04- Cable gland;
05- Acoustic sensor frame;
06- Vertical mounting base*;
07- Height-adjusting disc**.

* The Vertical mounting base allows positioning the acoustic sensor on the vertical, directly below the specimen, for measurements under the manual configuration.

** The height-adjusting disc should be used to balance CA-DP Acoustic Sensor and/or IED Impulse device heights, when testing lightweight specimens.

Sturdy Tripod



01- Frame;
02- Articulated tripod;
03- Handle for securing the tube;
04- Pillar;
05- Handle for the tube articulation;
06- Acoustic sensor clip;
07- Inner tube;
08- Handle for the inner tube articulation;
09- Outer tube;
10- Handle for the outer tube articulation;
11- Cable's organizer.

The Sturdy Tripod is supplied in the support automatic configuration and it is optional for the in manual configuration to measure the longitudinal vibration mode.

6. Specifications

Code 10-018-27

Model SA-BC-G2

Maximum dimensions for cylindrical specimens (L x D) ..... 450 x 200 mm

Minimum dimensions for cylindrical specimens (L x D) ..... 100 x 5 mm

Maximum dimensions for rectangular specimens (L x W x T) ..... 450 x 170 x 170 mm

Minimum dimensions for rectangular specimens (L x W x T) ..... 100 x 5 x 5 mm

Maximum weight when using Ø 0,7mm support-cable..... 10 kg

Maximum weight when using Ø 1,2mm support-cable..... 30 kg

Aperture between the support rods (minimum - maximum) ..... 62 - 200 mm

Aperture between the support-cables (minimum - maximum) ..... 15 - 275 mm

Support dimensions (W x L x H) ..... 360 x 230 x 270 mm

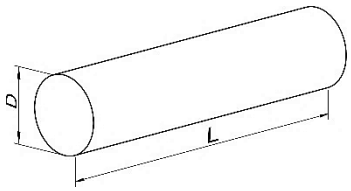
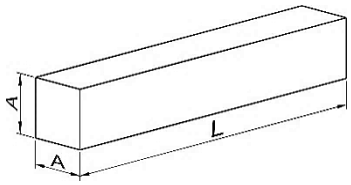
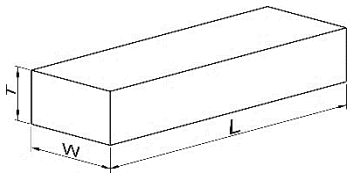
Support weight without a specimen ..... 4.2 kg

Working temperature range..... 10 - 40°C (50 - 104 °F)

7. Specimens

7.1 Recommended aspect ratios and typical dimensions

Minimum aspect ratios must be observed to avoid coupling between specimen's vibration modes. In addition, aspect ratio determines the pattern of frequency spectrum of the acoustic response. We advise users to standardize the aspect ratio in order to facilitate the frequencies identification. The table below presents the recommended aspect ratio and typical dimensions for bars and cylinders.

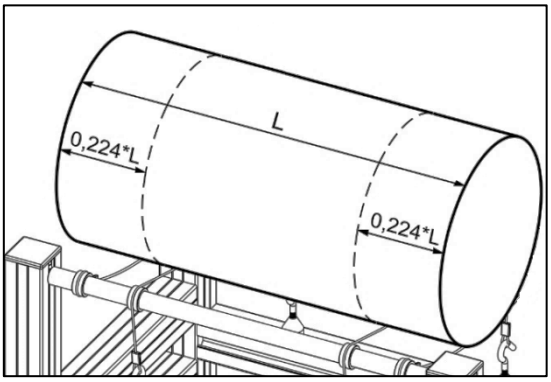
Geometry	Recommended aspect ratio	Typical dimensions
 Cylinder	$\frac{L}{D} \geq 2$ The ratio between length (L) and diameter (D) must be greater than or equal to 2.	(L x D) - 100 x 50 - 150 x 75 **- 200 x 100 mm** - 300 x 150 mm - 500 x 50 mm
 Square Section Bar	$\frac{L}{A} \geq 3$ The ratio between length (L) and edge (A) must be greater than or equal to 3.	(L x A x A) **- 150 x 25 x 25 mm** **- 150 x 35 x 35 mm** - 250 x 60 x 60 mm - 450 x 50 x 50 mm
 Rectangular Section Bar	$\frac{L}{W} \geq 4$ The ratio between length (L) and width (W) must be greater than or equal to 4. $\frac{W}{T} \leq 8$ The ratio between width (W) and thickness (T) must be less than or equal to 8.	(L x W x T) - 150 x 30 x 10 mm - 150 x 37,5 x 5 mm - 300 x 60 x 20 mm - 450 x 100 x 35 mm

Important observations for preparing and finishing the specimens:
- The recommended dimension tolerance is ±1%;
- Faces should be flat and parallel;
- Corners should not be rounded.

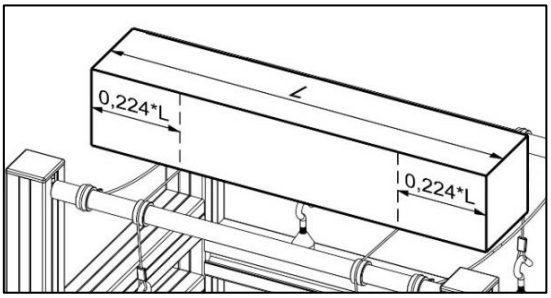
Note: *Minimum dimensions may vary as a function of aspect ratio and material Young's modulus; the frequency should be lower than CA-DP Acoustic Sensor and acquisition device maximum frequency. It is possible to estimate the frequency using Sonelastic® Software simulation tool. The higher the Youngs' modulus, the higher the frequency.*

7.2 Placing the specimen

The specimen should be symmetrically placed over the support-cables, with those at a distance of 0.224 L from the specimen ends (L is the specimen length). For instance, if a specimen's length (L) is 100 mm, the support-cables should be positioned at a distance of 22.4 mm from the ends. The positions of 0.224 L correspond to the nodal lines of the flexural vibration mode.



Typical positioning for a cylinder.



Typical positioning for a rectangular bar.

The corresponding distance calculation of 0.224 L is automatically generated and informed by Sonelastic® Software. The specimen marking may be done by using a pencil and a ruler or a caliper ruler. The Support-cables position is adjusted by dislocating the anchoring terminals.

8. Support installation

8.1 Requirements

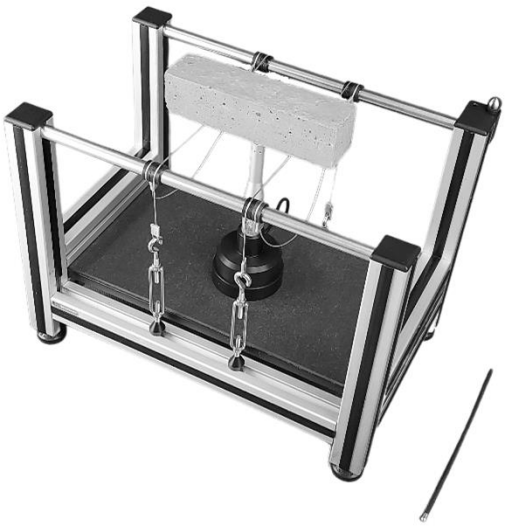
- A flat and leveled workbench with a free space of at least 60 x 120 cm (depth and width). This space is enough to fit SA-BC Support, specimens, computer and optional items.

- A 127 or 220 VAC three-pin ground wired electrical mains plug. This plug is needed to power the computer up.

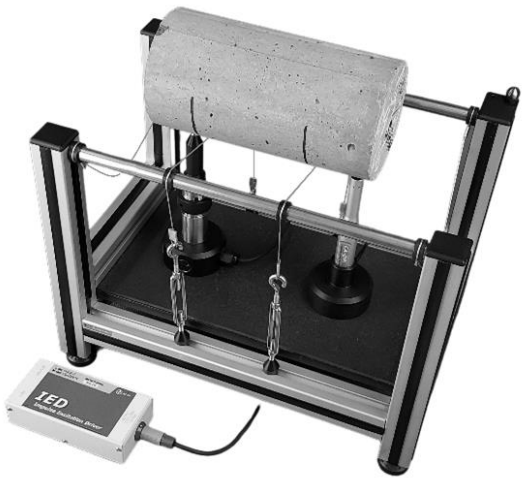
The support installation consists of positioning it over the workbench and coupling the acoustic sensor to the vertical base or Sturdy Tripod. Following that, choose the support-cables and install them.

8.2 Typical arrangements

Typical SA-BC Support arrangements are presented next.

[1] 	**Configuration:** Manual. **Specimen:** Square section bar. **Acoustic sensor:** With vertical mounting base and the height-adjusting disc. **Impulse device:** Light Manual Impulse Device.
[2] 	**Configuration:** Automatic. **Specimen:** Square section bar. **Acoustic sensor**: With vertical mounting base and the height-adjusting disc. **Impulse device:** IED Automatic Impulse Device with Medium RT Impulse Device and height-adjusting disc.
[3] 	**Configuration:** Manual. **Specimen:** Medium size rectangular section bar. **Acoustic sensor:** With Sturdy Tripod (optional item). **Impulse device:** Medium Manual Impulse Device.

Attention! Before using SA-BC Support, verify if its four rubber feet are on the workbench (not wobbly). If any of its feet is not flat on the workbench, readjust it until all feet are securely placed and flat on the surface.

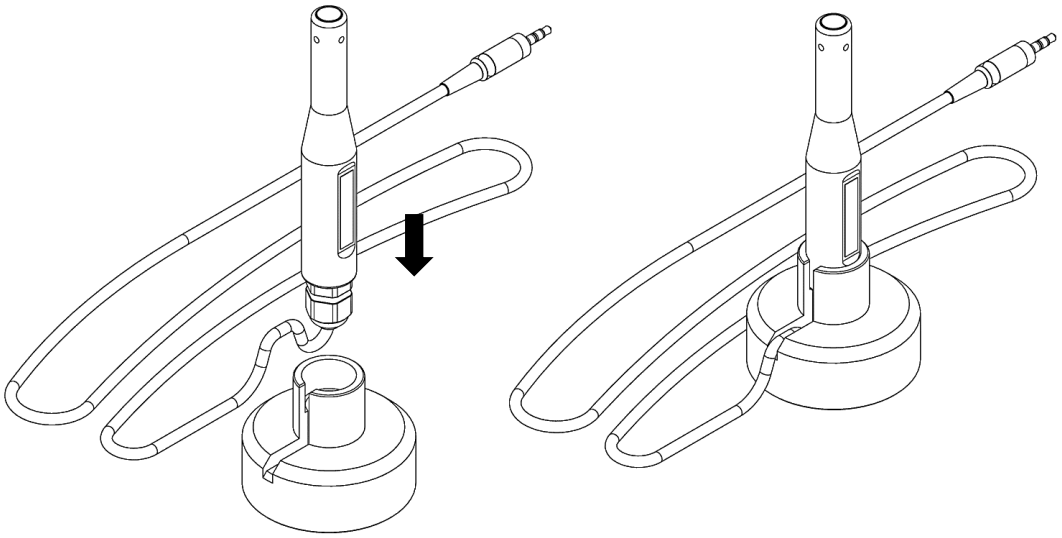
[4] 	**Configuration:** Manual. **Specimen:** Heavy cylinder. **Acoustic sensor:** With vertical mounting base, but without the height-adjusting disc. **Impulse device:** Medium Manual Impulse Device.
[5] 	**Configuration:** Automatic. **Specimen:** Heavy cylinder. **Acoustic sensor:** With vertical mounting base. **Impulse device:** IED Automatic Impulse Device with Medium RT Impulse Device.
[6] 	**Configuration:** Manual. **Specimen:** Medium size rectangular section bar. **Acoustic sensor:** With Sturdy Tripod (optional item). **Impulse device:** Medium Manual Impulse Device.

Note: *In the typical arrangements presented, the optimum support form for the flexural mode is also proposed for the longitudinal mode. Nodal lines and the ideal support for this vibration mode do not match the ones for the longitudinal mode. However, the longitudinal mode is very little sensitive to the cables supporting positions (when ends are free). As a result, it is possible to use the flexural mode boundary conditions to characterize the longitudinal without compromising the results.*

8.3 Mounting the acoustic sensor in the vertical base and Sturdy Tripod

In the vertical mounting base:

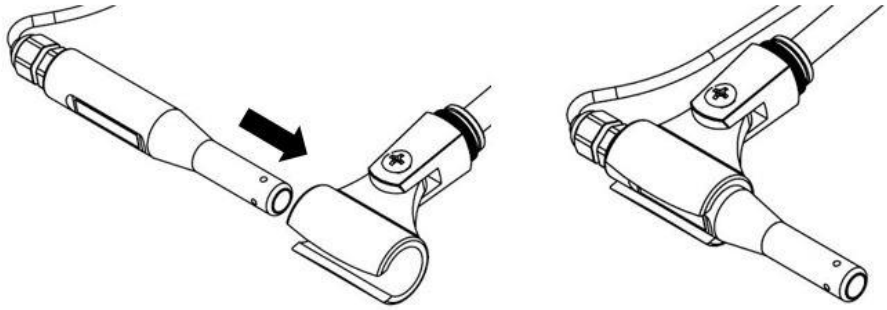
Step 01 - Insert the acoustic sensor in the vertical mounting base ensuring the wire goes out through the side opening, as shown below:



Step 02 - Press the base against the acoustic sensor until it is coupled and secured to the base.

In the Sturdy Tripod:

Step 01 - Insert the acoustic sensor in the Sturdy Tripod acoustic sensor clip, as shown below:



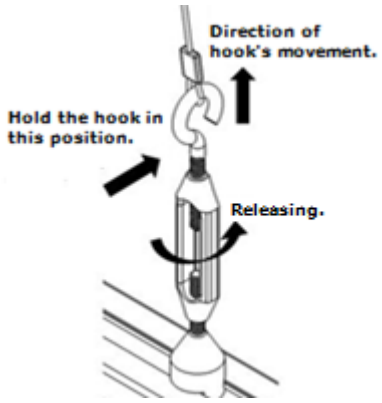
Step 02 - Slide the acoustic sensor into the clip until the whole acoustic sensor frame is fully secured, then place its cable over the Sturdy Tripod inner tube.

Step 03 - Connect the acoustic sensor to the acquisition board audio input.

8.4 Replacing the support-cables

The thinner the support-cable, the smaller is its interference in the measurement. However, observe the maximum weight than can be held by each of the two support-cables available. SA-BC Support is supplied with a Ø1.20mm support-cable set (this is the recommended cables to be used with specimens weighting between 10 and 30kg). To replace them for the Ø0.70mm support-cables (recommended for specimens weighting up to 10kg), follow the steps described next:

Step 01 - Turn the support-cable tightener anti-clockwise until the support-cable is completely loose. Hold by the hook when turning the tightener to prevent the cable from turning with it;



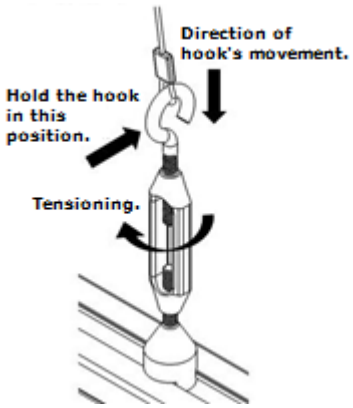
Step 02 - Disconnect the support-cable ends (eye nuts) from the respective hooks (tightener terminal and anchoring terminal);

Step 03 - Repeat the previous steps to uncouple the other support-cable;

Step 04 - Hold the new support-cable to be used and couple the eye of one of its ends to the anchoring terminal hook;

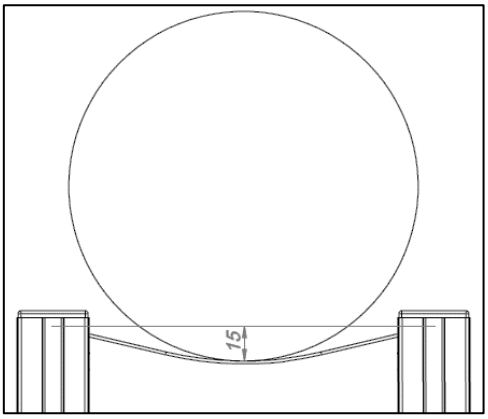
Step 05 - Maintaining the new cable under a slight tension, place it on the tubes, ensuring it fits perfectly the chute of each one of the three supporting sleeves of the support-cable. Next, couple the other cable eye nuts to the tightener terminal hook;

Step 06 - Holding the hook as illustrated in Step 01, turn the tightener clockwise so that the new support-cable is tight;



Step 07 - Repeat the previous steps to fit the other support-cable.

For light specimens (weighting up to 10kg), tension the support-cables until fully straight. For heavy specimens, adjust the tension on the cables so that, when the specimen is placed over them, it will only go down about 15 mm from its initial position, as shown below:



Necessary displacement for heavy specimens using Ø1,20 mm support-cables.

If the displacement is less than 15 mm in the case of heavy specimens, the support cables will be overloaded and may rupture.

8.5 Installing the IED Automatic Impulse Device

Before installing the IED Automatic Electromagnetic Impulse Device (controller and device), please read its own Instructions Manual.

9. Support operation

After following *8 – Support Installation steps*, the SA-BC Support will ready for use.

9.1 Positioning the specimen

To carry out a fast and precise characterization of specimens using SA-BC Support:

Step 01: Install the support according to the specimen weight (see *8 – Support Installation*);

Step 02: Using a ruler or a caliper ruler and a pencil, trace nodal lines on the supported face and on the sides of the specimen. These lines should be 0.224 L distant from the ends being L the length of the specimen (see *7.2 - Placing the specimen*);

Step 03: Shift the tighteners, terminals and sliding support sleeves together with their respective support-cables until the distance between them allows to support the specimens exactly by their nodal lines (0.224 L);

Step 04: Place the specimen over the Support-cables ensuring that the nodal lines traces are precisely aligned with the cables under it.

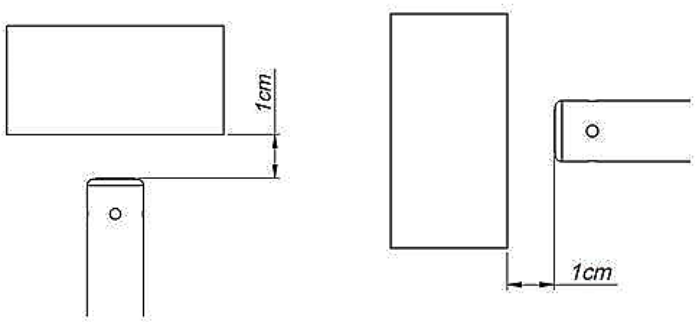
After completing these steps, the specimen should be correctly supported and positioned for the characterization.

Note: *To measure the torsional mode in rectangular bars, it is necessary to trace lines at 0.32 L for acquisition and excitation. For more details, please verify 10 - Acquisition and Excitation Modes.*

9.2 Positioning the acoustic sensor

Step 01: Mount the acoustic sensor in the Sturdy Tripod clip or in the vertical mounting base, as described in *8.3 – Mounting the acoustic sensor in the vertical base and on the Sturdy Tripod;*

Step 02: Adjust the height or distance of the acoustic sensor, so its end is at a distance of approximately 1 cm away from the specimen, as illustrated below; *Note: The distance is not critical for the results.*



Step 03: Position the Acoustic Sensor. It may be in line with the center of the inferior face of the specimen, when focusing on the flexural mode; in line with and above the specimen, when focusing on the longitudinal mode; or to the side of the inferior face (near the Support-cables at the 0.32 L position), when aiming to obtain both flexural and torsional modes.

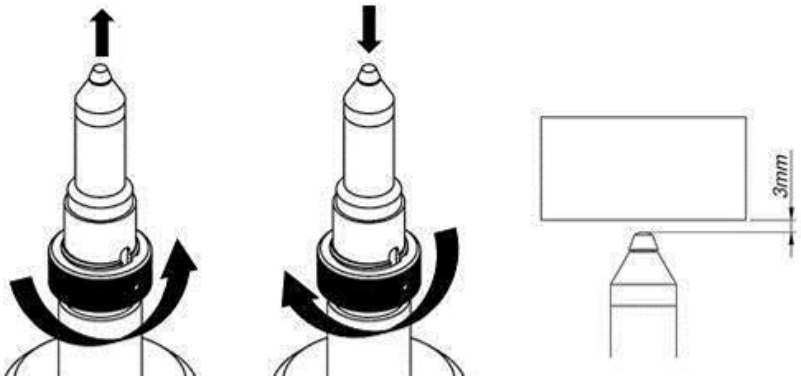
Note: *For more details on the correct positioning of the Acoustic Sensor, verify 10 – Acquisition and Excitation Modes.*

9.3 Positioning the IED Automatic Impulse Device

Step 01: Check if the RT Impulse Device is directly below the center of the inferior face of the specimen if the focus is on the flexural mode; or to the side of the inferior face (0.32 L) to measure flexural and torsional modes;

Note: *For more details on how to correctly position the Impulse Device, see 10 – Acquisition and Excitation Modes;*

Step 02: Turn the adjusting nut of the Impulse Device clockwise and anticlockwise to allow the vertical movement of its tip. Adjust the position so it remains approximately 3 mm away from the specimen, as pictured next:



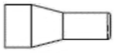
Step 03: Configure the Impulse Device intensity (see more information in the IED Impulse Device User Manual.

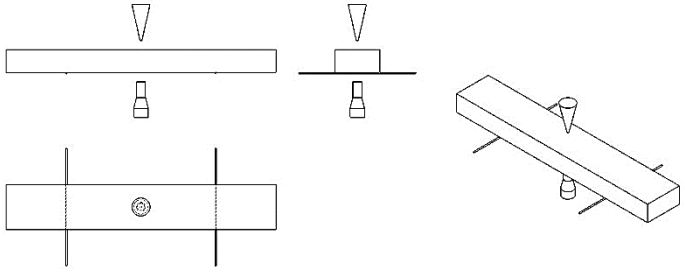
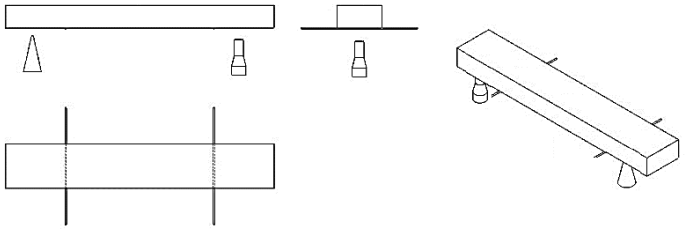
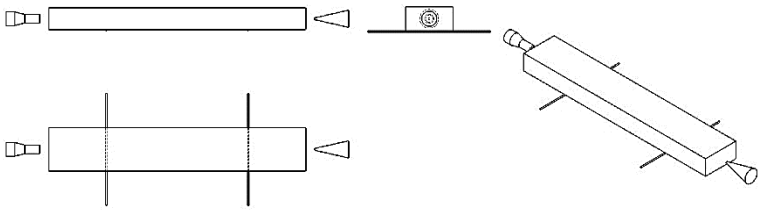
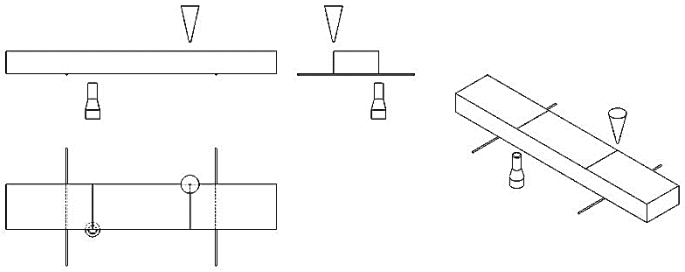
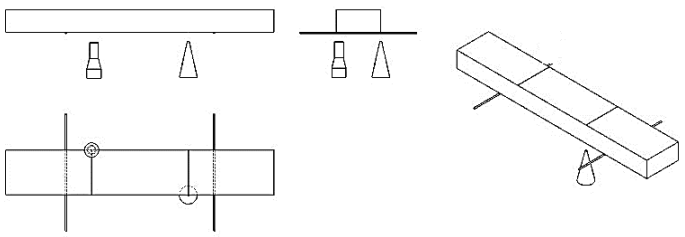
Note: *All information regarding the IED Automatic Electromagnetic Impulse Device has been described in detail in its Installation and Operation Manual.*

Attention! When dealing with heavy specimens, ensure safety cables are always positioned close by the support-cables to avoid chances of specimens falling over the user hands in the case of a support-cable rupturing.

10. Acquisition and excitation modes

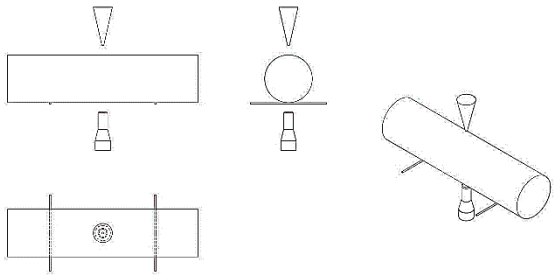
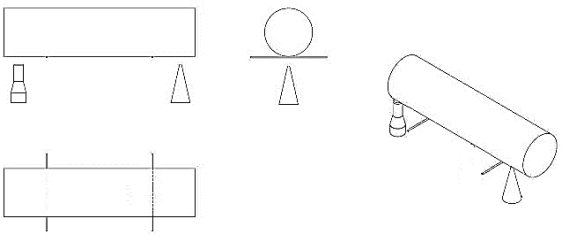
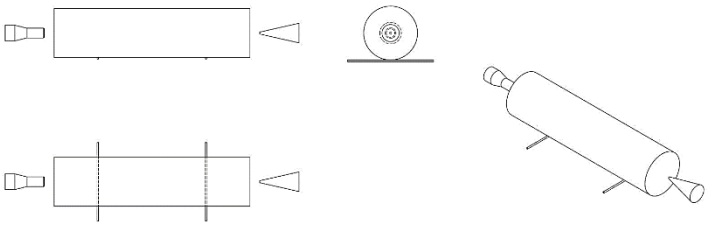
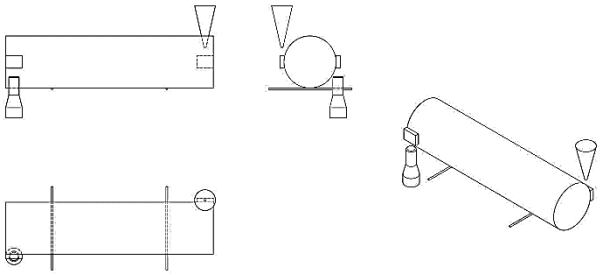
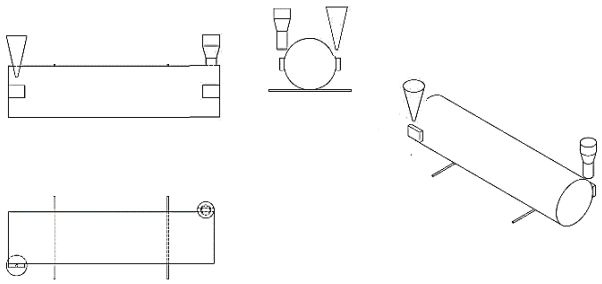
The table below describes the most practical positions of the acoustic sensor and impulse device for characterizing rectangular specimens, using flexural, torsional and longitudinal vibration modes.

Impulse:  Acoustic sensor: 

Flexural mode – I *Excitation from above and signal acquisition from below, both aligned with the center of the specimen.* *Cables positioned at 0.224L.*	
Flexural mode - II *Excitation and signal acquisition from below, both on the specimen ends.* *Cables positioned at 0.224L.*	
Longitudinal mode *Top-centered excitation and signal acquisition from opposite sides of the specimen.* *Cables positioned at 0.224L.*	
Flexural + torsional modes - I *Excitation from above and signal acquisition from below, positioned at 0.32L from opposed edges.* *Cables positioned at 0.224L.*	
Flexural and torsional modes - II *Excitation and signal acquisition from, positioned at 0.32L on opposed edges.* *Cables positioned at 0.224L.*	

The next table provides additional information focused on cylindrical specimens.

Impulse: Acoustic sensor:

Flexural mode - I *Excitation from above and signal acquisition from below, both aligned with the center of the specimen.* *Cables positioned at 0.224 L.*	
Flexural mode - II *Excitation and signal acquisition from below, both at the specimen ends.* *Cables positioned at 0.224 L.*	
Longitudinal mode *Top-centered excitation and signal acquisition from opposite sides of the specimen.* *Cables positioned at 0.224 L.*	
Flexural + torsional modes - I *Excitation from above and signal acquisition from below from opposite sides and ends.* *Cables positioned at 0.224 L.*	
Flexural + torsional modes - II *Excitation and acquisition from above from at opposite ends side.* *Cables positioned at 0.224 L.*	

Considering the arrangements presented to the signal acquisition of torsional and longitudinal modes, positioning the support-cables at a distance of 0.224L is not ideal and it may affect damping measurements, however it has minimum influence (<0.1 %) when determining Young's Modulus.

11. Warnings and support transportation

⚠ Reading all the information contained in this Installation and Operation Manual is compulsory for the correct use of the support;
⚠ The power outlet where the computer will be connected must have a functional ground pin;
⚠ Do not use this support for other purposes apart from the ones specified by this manual;
⚠ The non-compliance with the instructions provided by this manual in what regards the use of the support may reduce or invalidate warranty time.

Support transportation:
- Transport the support with care;
- Avoid impacts and falls when transporting the support;
- Do not transport the support under rain or snow, even when wrapped in its original packaging.

12. Maintenance and troubleshooting

- Depending on the specimen material, detachment of residues may occur during handling. To avoid hazards and possible damages to the support, clean frequently using a slightly damp cloth.
- To maintain the support in a good condition and extend its life, keep all accessories, optional items and chutes clean.

Troubleshooting:

Problem	Possible Cause	Solution
Locked (unable to move) tightener and/or anchoring terminal.	The terminals sliding chutes may be dirty or blocked.	Vacuum the chutes and remove any object or residue that may be obstructing it.
The support wobbles when placed over a bench.	The bench surface may not be completely flat or may present some irregularities.	Adjust the rubber feet until they are all well placed and flat on the surface.
The specimen touches the safety cables and it disturbs the measurements.	Specimen weight is above the limit or the Support-cable is not under enough tension.	Check the weight limits in *6 – Specifications*. Check the correct way to apply tension to the support-cables in *8.4 –Replacing the support-cable set.*
The specimen does not fit between the cables supporting tubes.	Specimen dimensions are above the limit.	Check dimensions limits in *6 – Specifications.*

13. Symbology

Attention! Risk of danger.

14. Technical support and warranty

If the support presents any abnormality, verify if the problem is listed in *12 – Maintenance and troubleshooting*. If the problem still cannot be fixed, contact ATCP.

ATCP Physical Engineering offers a 12-month warranty with this support, starting from the date of purchase. It covers manufacturing defects or materials defects, but some factors may cause the invalidation of warranty:

1 - The non-compliance with the recommended care regarding the installation and operation of this support, as describe herein;

2 - Accidents, falls, inadequate installation or any other damage cause by incorrect use or action of natural agents;

3 - Violation, repair or any other modification or alteration done in the support or parts of the support carried out by non-authorized agents (non-authorized by ATCP Physical Engineering).

After the 12 months of warranty, parts, expenses and services shall be charged.

15. Statement of responsibility

ATCP Physical Engineering takes total technical and legal responsibility over the SA-BC Support and guarantees that all information here provided are true.

Notes: