J.W.LEMMENS N.V.

Dynamic Materials Testing

Operation Manual

GrindoSonic

MK5“Industrial“

Operation Manual Grindo*Sonic* MK5

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1. Specification

Model:	MK5“Industrial“
Electrical Supply:	230 V / 50 Hz (110 V / 60 Hz), 20 W typically
Compliance	Safety Regulations for Laboratory Measuring Instruments according to EN 61010 and Electromagnetic Susceptibility Industrial Use according to EN 50082
Housing:	Robust metal housing – suitable for industrial environments
Dimensions	40 x 30 x 14 cm
Weight:	9.5 kg
Frequency Range:	20 Hz – 100 kHz
Accuracy and stability:	better than 0.005%
Modes of vibration detection:	• Flexural Vibration • Torsional Vibration • Longitudinal Vibration
Test object specifications:	• E-Modulus range from < 100 MPa to > 850 GPa • Weight from < 0.5 g to > 1000 kg
Geometries for E-modulus calculation:	• bar shaped, rectangular cross section • bar shaped, round cross section (cylinder) • discs
Display:	Dot-Matrix LED, 11 mm height
Display resolution:	3, 4, 5 digits
Display modes:	• Frequency F (Hz – kHz), • Time T (µs – ms) • Classic Reading R - identical to MK3/MK4 instruments
Digital outputs:	• 2x independent RS232 for PC data input and control e.g. the Elevated Temperature Measurement and Testing System (ETMTS) for Grindo*Sonic* • Trigger Out for control of automated measurements
Analogue outputs	• Analogue output for oscilloscope connection
Digital inputs:	• Command-In for control of automated measurements • Marker-In for identifying two different modes of vibration

2. Introduction

Grindo*Sonic* instruments are designed for measuring elastic materials characteristics for both materials scientists and industrial engineers. The non-destructive nature of the test and the speed and ease of the operation allow any number of repeat measurements to be made on one test object and/or to follow the components material characteristics through its useful life.

Large numbers of items may be measured easily, bringing the concept of 100% testing to reality.

Grindo*Sonic* measurements are possible on an almost limitless range of materials of vastly varying geometries.

The Grindo*Sonic* system is based on the Impulse Excitation Technique, which has been approved by international standards such as

> ASTM E1876, ASTM C1259, ASTM C1548, ASTM C215, EN 843-2, EN ISO12680-1, EN 14146 and others.

Grindo*Sonic* instruments are in use worldwide for more than 35 years and in over in 57 countries, both in scientific institutes as well as in numerous industries.

The main advantages of this method are:

- Non-destructive nature of the test
- Simplicity and speed of the measurement
- Very high accuracy of the measurement
- Extremely fast availability of calculated material constants with highest accuracy
- No calibration or adjustment is required
- Exceptional reliability and longevity of the equipment.

3. Summary of Method

Impulse Excitation Technique

Grindo*Sonic* measurements are based on the impulse excitation technique. The method covers a dynamic determination of the elastic properties of materials. The procedure comprises of firstly exciting a test object by means of a light external mechanical impulse, and secondly of the analysis of the transient natural vibration during the subsequent free relaxation. This excitation is given in such a way as to favour the desired vibration mode:

- a flexural vibration
- a torsional vibration
- or a longitudinal vibration

The vibration and the test objects first harmonic is being analysed during the phase of free vibration and being shown on the instruments display either in Hz or in µs/ms or as the Grindo*Sonic* Reading value.

A transducer is used to pick up the mechanical vibration. The analogue signal from the vibration detector is fed to a two-stage linear amplifier. A zero crossing detector will accurately mark off the signal periods. As soon as the peak detector senses that the incoming signal starts decaying, the data is validated and the successive period measurements commence. The instrument records all available periods and stores the result in the microprocessor memory for further analysis. When the incoming signal has decayed the processor selects the measurement corresponding to the purest waveform and displays the result on the front panel.

Grindo*Sonic* instruments use a high precision reference oscillator with extreme permanent accuracy, hence no calibration is required.

In general all materials with elastic material properties and not exceeding excessive internal damping (such as water or foam) can be measured. Also in general no specific care has to be taken with regards to dimension and size, as long a reproducible basic harmonic vibration can be excited. The weight can vary between 0.1g up to 2 tonnes. For Young's modulus calculation however formulas are being given for specific shapes.

The range of moduli can also be very wide. Presently, the method has been used to measure elastic moduli from about 100 N/mm² (MPa) to 850 kN/mm² (GPa).

Measurements have been performed at temperatures ranging from -265 °C to +1500 °C. For high temperature measurements please refer to the Grindo*Sonic* ETMTS system of J.W. Lemmens N.V.

The test is very easy to perform and requires only very little time. Hardly ever does the test itself last more than a few seconds. Furthermore, for the impact only an extremely small force has to be applied on to the specimen. In this way the frequencies are measured at the origin of the stress-strain curve and therefore give the intrinsic or tangent moduli. The test is totally non-destructive.

The non-destructive nature of the test together with the speed and ease of the process allow 100%-testing of high volume productions in industrial quality control applications.

The measurement results appear on the front panel in one of the following forms:

- f Frequency (factory setting) in Hz or kHz
- R classic Grindo*Sonic* Reading
- T Period (2 periods, same as R but in µs or ms)

The option **Frequency (F)** displays the actual frequency of the fundamental vibration.

Traditional Reading (R) This is the duration of 2 periods of the fundamental vibration, expressed in microseconds. The result may be a number of two to five digits without a decimal point. No units are displayed.

Time Reading (T) is also the duration of 2 periods of the fundamental vibration. However, the result is now displayed in a constant resolution format and with a unit dimension. Depending on the setting of the front panel buttons, the result will have 3, 4 or 5 significant digits over the whole range. This format requires inclusion of a decimal point and the display of units (milliseconds or microseconds).

The relation between the Reading (R), Time (T) and Frequency (F) is as follows:

$$f = \frac{2000000}{R}$$ R (or T in µs) = Reading, f = frequency in Hz

$$f = \frac{2000}{T}$$ T = Reading in ms, f = frequency in Hz

All signals are available at 2 serial data output ports for remote analysis via a PC, for sample handling and/or for automation applications.

When in manual mode, the instrument is reset after 750 ms display time and immediately ready for the next measurement.

4. User's Guide – MK5 ”Industrial”

4.1. First steps

Before using the instrument for the first time please make sure all supplied accessories are available - for a list of supplied accessories see page 20. The instrument must be connected to a 230 VAC (or for US 110 VAC) using the supplied mains cable. Check that a proper earth connection is provided. A socket at the instrument front allows for connection of the Grindo*Sonic* vibration detector, either a piezoelectric detector or a microphone (for operation refer to chapter 4.4 page 19). After connecting the instrument to mains and switching on using the main switch at rear of instrument, a system message “Dynamic Materials Testing” appears and the top LED indicates the system being immediately ready for measurements. For new operators it is recommended to use the ceramic test bar (supplied with a new Grindo*Sonic*) for firsts trials – see also chapter 5 page 21 ff.

4.2. Instrument Front Panel

Illustration 1: Front of MK5 “I”

The functions of the MK5 front panel – from left to right – are:

4.2.1. Status-LEDs

Located above the detector socket are 2 red LEDs. The top LED is illuminated continually after switching on mains power – the instruments is immediately ready for measurements. The bottom LED lights up during acceptance and analysis of a valid vibration.

Illustration 2: LEDs/Detector socket

4.2.2. Signal Input Socket for Detector or Microphone

Located at the front left hand side of the instrument is the detector input socket. When plugging the piezoelectric vibration detector or the acoustic microphone in to the socket the red dots on plug and connector must be aligned. Please note that the plug of the detector or microphone incorporates a locking feature. To unlock this mechanism and remove the connector hold the connector at the serrated part while withdrawing the connector. **Important**: It is not possible to remove the plug by pulling at the cable.

4.2.3. DIP Switches

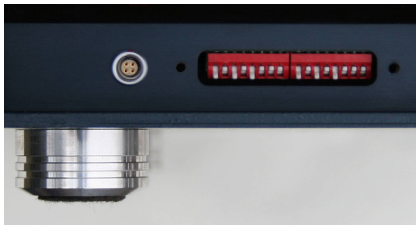


Illustration 3: DIP Switches

Under a metal plate to the right of the detector socket (showing the text MK5"Industrial") are 2 DIP switches to configure the corresponding serial ports COM 1 and COM 2 at the rear of the instrument. The cover plate can be unscrewed. For more information and settings see chapter 4.3.9 page 16.

4.2.4. Display

In the centre of the front panel the LED matrix display the measuring results. The first 6 digits are for display of the value, the last 3 are for the display of units (kHz, µs …).

4.2.5. Push Buttons for Resolution Settings

Located at the right hand side of the front panel are 3 push buttons (stay-put action):

left push button: displayed value with 3 digits
middle push button: displayed value with 4 digits
right push button: displayed value with 5 digits

Illustration 4: Resolution

Note: This option can be used, if the factory setting or the setting at the rear of the instrument needs to be changed during operation. The factory settings can be modified using the <3/4> toggle switch at the rear – its function is always active when switching on the instrument, see chapter 4.3.8 page 15.

4.3. Rear Panel of Instrument

Illustration 5: Rear Panel MK5"i"

4.3.1. Mains Switch

Located at the left hand side are the power switch and the power cable socket. For Europe Grindo*Sonic* is set to 230 VAC – for the US the instrument is set to 110 VAC.

4.3.2. Fuse

Fuse and spare fuse can be found behind a small cover between power switch and power cable socket.

4.3.3. Serial Data Outputs

The instrument is equipped with 2 serial RS232 output ports (PORT1 and PORT0). The communication settings such as baud rate etc. can be selected using the two DIP switches located at the front of the instrument – under the cover with the text MK5”Industrial”.

The 2 com ports can separately control or send information to attached device, such as printers or a PC. Note: the com ports and attached devices must have the same communication settings.

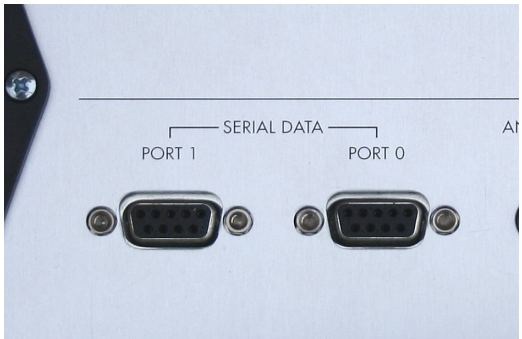


Illustration 6: Serial Ports

For options and settings please refer to chapter 4.3.9 page 16.

4.3.4. ANALOGUE OUTPUT

The socket next to the serial ports is the analogue output for a visualisation of the vibrational signal via an oscilloscope – see illustration 7. For the necessary cable see chapter 4.6 page 20 or contact J.W. Lemmens N.V.

4.3.5. TRIGGER OUT

The trigger out function is for automated systems. When a signal is being detected and processed, a positive pulse is provided at the Trigger Out socket. The falling edge of this pulse can be used to indicated that a measurement has been processed by Grindo*Sonic* and that the test object and the detector may now be removed to prepare for the new measurement.

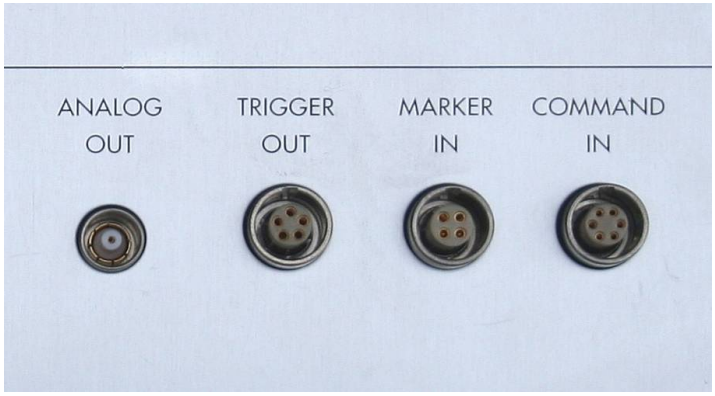


Illustration 7: Inputs / Outputs

4.3.6. MARKER IN

The socket marked 'MARKER IN' has been designed to distinguish between two measurement modes (e.g. flexural and torsional vibration) of the same test object. The RS-232 lines will output a '+' after a measurement when the 'MARKER' contact is open and a '-' when the 'MARKER' contact is closed. In our example, a software programme in an automatic set-up can now positively interpret an incoming measurement as a flexural or torsional vibration.

4.3.7. COMMAND IN

This is remote control function for the instrument or automated measuring systems in production testing facilities. An external switch (such as a foot switch or a machine actuated switch) can be connected to the instrument. When connected, closing the switch will activate the instrument, a measurement can be performed and processed by Grindo*Sonic*. After this single measurement no further signal processing can be done until the external switch is first released and then closed again. This is to avoid any false reading to be recorded during the handling of the probe or the test object. The instrument automatically switches to this mode when it senses a cable is connected to the 'COMMAND IN' socket.

COMMAND IN OPTIONS (when a cable is connected):

Contact **closed**	Instrument **ready** for measurement
Contact **open**	Instrument **not ready** for measurement

Note: After a measurement the contacts must be **opened and then closed** in order to perform a new measurement.

4.3.8. Format of Display Value and Resolution Settings

At the right of the rear panel located are 3 toggle switches, which determine the format of the displayed value when switching on the instrument.

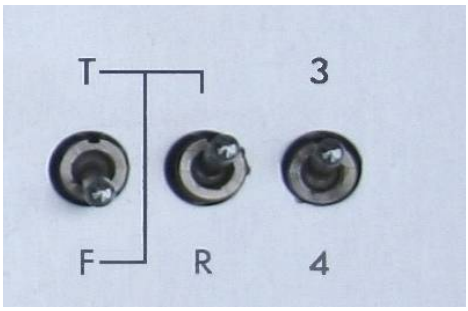


Illustration 8: Display Value Resolution

Traditional reading **R** (middle switch)

The middle switch determines whether the format is traditional reading or not. With the switch in the 'R' position, the two other switches will have no effect.

Frequency/Time **F/T** (left switch)

The switch marked T/F changes the measurement result from time to frequency (T in µs/ms and F in Hz/kHz). Note: The <R> needs to be in the upper position.

Resolution **3/4** (right switch)

The right switch marked 3/4 sets the default resolution of the displayed result. The position of this switch determines the resolution of the displayed result when the instrument is switched on. It is possible to change this resolution through a front panel push button. But the setting of the front push buttons is lost whenever the instrument is switched off.

4.3.9. DIP Switches - Options

The format of the data sent from the instrument through the RS232 serial lines to a connected device is defined by DIP switches – accessible behind a black cover with the text MK5 "Industrial" on the front side of the instrument see Illustration 9.

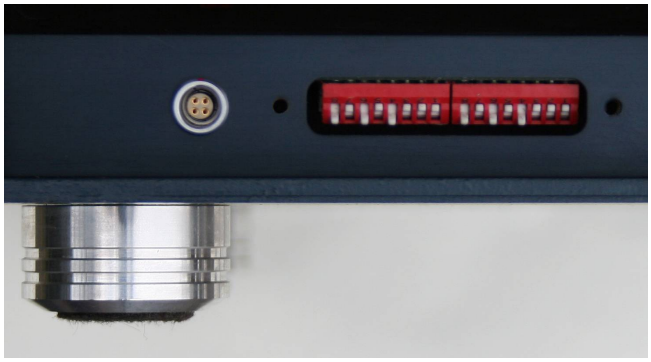


Illustration 9: DIP Switches

Left DIP switch PORT **0**
Right DIP switch PORT **1**

Switch in illustration **up** **<=>** **Closed**
Switch in illustration **down** **<=>** **Open**

For each device connected a separate com port setting is necessary – the settings have to be the same for the instrument and the connected device.

Note: Changes of the Dip switch settings can only be made with the instruments switched off.

Switch 8 – 4

Switch	**8**	**7**	**6**	**5**	**4**
Closed	serial comms disabled	no parity	parity odd	1 stop bit	7 data bits
Open	serial comms enabled	parity	parity even	2 stop bits	8 data bits

Switch 3 – 1

Baud rate	**3**	**2**	**1**
9600	Closed	Closed	Closed
4800	Open	Closed	Closed
2400	Closed	Open	Closed
1200	Open	Open	Closed
600	Closed	Closed	Open
300	Open	Closed	Open
150	Closed	Open	Open

These are the factory settings for the Dip switches

Transmit serial comms enabled
Baud rate 9600
Data format 8 data bits, 1 stop bit, no parity

4.3.10. Pin Assignment 9 way D-Sub RS232 Socket

Pin 1	GND
Pin 2	TXD
Pin 3	RXD
Pin 4	RTS
Pin 5	CTS
Pin 7	GND
PIN 8	+12V

4.3.11. Character String of Serial Outputs

<S>	Space
<CR>	Carriage Return
<LF>	Line Feed
1	One character

Notes: The character '**+**' is replaced by '**-**' if the contact with the function <MARKER IN> is closed.

The number of characters sent through the RS232 lines always counts 11.

Format: Display in µs/ms with 3 digits

<S>11.1ms<S>+<CR><LF>
<S>1.11ms<S>+<CR><LF>
<S><S>111µs<S>+<CR><LF>
<S>11.1µs<S>+<CR><LF>

Format: Display in µs/ms with 4 digits

11.11ms<S>+<CR><LF>
1.111ms<S>+<CR><LF>
111.1µs<S>+<CR><LF>
11.11µs<S>+<CR><LF>

Format: Display in Hz/kHz with 3 digits

<S>11.1kH<S>+<CR><LF>
<S>1.11kH<S>+<CR><LF>
<S><S>111Hz<S>+<CR><LF>
<S>11.1Hz<S>+<CR><LF>

Format: Display in Hz/kHz with 4 digits

11.11kH<S>+<CR><LF>
1.111kH<S>+<CR><LF>
111.1Hz<S>+<CR><LF>
11.11Hz<S>+<CR><LF>

Format: 'Traditional' Reading

11111<S><S><S>+<CR><LF>
<S>1111<S><S><S>+<CR><LF>
<S><S>111<S><S><S>+<CR><LF>
<S><S><S>11<S><S><S>+<CR><LF>

4.4. Vibration Detection

4.4.1. Piezoelectric Detector

Illustration 10: Detector

The piezoelectric detector is a very versatile piece of equipment. It will cover the entire frequency range of the Grindo*Sonic* which is about 40 Hz to 100 kHz. It is made of a sensitive piezoelectric element and an electronic pre-amplifier and gives long and trouble-free service when treated with reasonable care. Please note that the detector is direction sensitive. A dot on the detector housing indicates **the direction of maximum sensitivity, which must be observed during measurement.** The dot must always be held in the direction of the vibration.

Illustration 11: Detector Marker

When holding the detector especially to small test objects please avoid as best as possible additional damping - for instance by pressing the detector too hard against the test object or moving the test object. A light but proper contact with the test object should achieve best results. If a proper contact with very small objects is not possible use the microphone.

Important: When plugging in the detector to the front panel socket the dot on the connector housing must line up with the dot on the socket. When removing the locked detector make sure that the connector is held at the serrated part while unplugging it.

4.4.2. Acoustic Microphone

Another means of detecting the vibrational motion is the acoustic microphone. The advantage of the microphone is that no contact is made with the test object to avoid additional damping. It is clear however that a microphone can only be used in relatively quiet surroundings. Also the frequency bandwidth of a microphone is smaller compared to the piezoelectric detector.

Illustration 12: Microphone

Important: When plugging in the microphone to the socket on the front panel, the dot on the connector housing must line up with the dot on the socket. When removing the locked microphone make sure that the connector is held at the serrated part while unplugging it.

4.5. Accessories supplied with the Grindo*Sonic* Instrument

- 1 Mains Cable
- 1 RS232 Cable
- 1 Piezoelectric Detector
- 1 Microphone
- 1 Software CD for Young's modulus calculation – see chapter 6 page 27 ff
- 1 Ceramic Test and Calibration Bar
- 1 Operating Manual
- 1 Set of Tapping Devices

With the instrument a ceramic test bar is supplied with which the first operation can be practised and checked against the manual. It is quite easy to measure all given vibration types (flexural, torsional and longitudinal) of this ceramic test bar on a simple and soft foam mat (supplied with the instrument). No care has to be taken for special supports of this specimen in the vibrational nodes. For the measuring technique and vibrational nodes see chapter 5 page 21 ff. A measuring certificate accompanies the test bar with which the accuracy of the instrument can be checked and validated during the life time of the instrument.

4.6. Optional Accessories

- Low frequency microphone filter
- Foot switch for connection to the COMMAND IN socket
- Oscilloscope cable (socket ANALOGUE OUT)
- Table Top Microphone stand manual excitation
- Table Top Microphone stand air pressure excitation
- Semi automatic measuring station SAMTA
- Elevated Temperature Measuring Station ETMTS, up to 1200°C (Type 4B0)

5. Measuring with the Impulse Excitation Technique

5.1. Bar Shaped Samples

5.1.1. Bars – Fundamental Flexural Vibration Mode

The fundamental flexural vibration mode of a bar with a constant cross section will present a maximum deviation in the centre and at both ends. Two nodal lines (amplitude = 0) are located at 0.224xL (L=Length) from the ends. If the bar has a width of no more than 1/3 of the length, the nodal lines can be considered straight lines.

Illustration 13 demonstrates tapping and detection of the fundamental flexural vibration of a test object with the dimension approx. 150 x 40 x 10 mm. The test object is supported by two foam strips in the nodal lines (0,224 x length from left and right end) to eliminate additional damping caused by the support as best as possible.

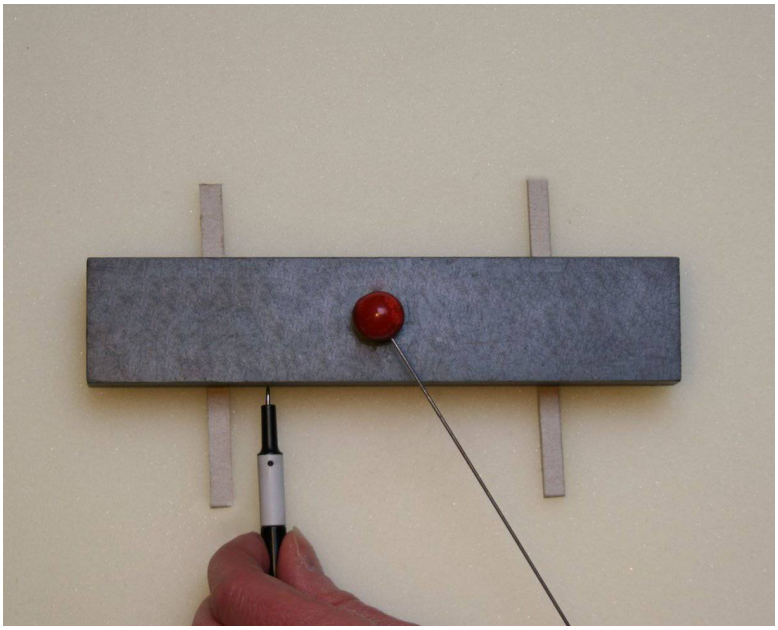


Illustration 13: Bars – Flexural Vibration

Often it is sufficient to put a test object of this size simply on a foam mat and ignore the vibrational nodes. However the greater the length to thickness ratio, the more carefully the supports must be chosen and positioned.

To excite the test bar in the desired flexural mode a **light and elastic tap** shall be given, preferably in the centre of the bar (in illustration 13 from the top) where most of the excitation impulse will be converted into the desired flexural vibration. The centre is the preferred point of impulse because of the symmetry and the stability of the sample. Indeed, a tilting movement of the bar is not desirable.

When the detector is brought in to contact with the test object a meaningless number will generally come up on the display. After aprox. 1 seconds this will be cleared automatically and the proper measurement can be initiated.

One can not stress enough that the exciting impulse should be very light and elastic. Indeed very little energy is required for the measurement. Elastic means that the impacting object must bounce back immediately. The tapping object is not at all critical, however best results are achieved if the centre of gravity (of the impact device) is exactly in the point of impact. Therefore the use of a spherical object at the end of a thin flexible stem is suggested. The flexible stem can be a tie wrap – this is ideal as it flexes only in one direction! The size and material for the ball of the hammer shall be chosen considering the size and the shape of the test object. The shorter and thicker the sample and the harder the material, the harder the material for the impact should be. As an example: for a rather slim bar of 150 mm length and 10 mm thickness, made of relatively low modulus material (e.g. glass), a hard rubber ball is suggested, about 1/2 inch (12 mm) in diameter at the end of a thin steel wire about 5-6 inches (10-12 cm) long.

To capture the vibration and convert this into electrical signals the hand-held piezoelectric vibration detector should be used. On the detector housing a dot indicates the direction of maximum sensitivity. Always hold the dot in the direction of the amplitude vibration – in this case vertical.

The point of the detector must be brought in to contact with the test bar in order to pick up the vibration. Please note a slight contradiction: for the set-up special precaution may have been taken in supporting the sample and tapping the specimen so that it would be free to vibrate. However, the rigid steel point of the detector is likely to dampen the signal or at least to induce some external stiffness.

Instead of touching the bar in the centre (point of maximum vibration), it is preferred to choose the point of contact away from the centre towards one node and may be close to the node (but not exactly in the node as we would have no signal - see illustration 13). You will see a noticeable delay between the tap and the display of the result of the measurement to ensure a very high reproducibility of the readings.

Glass samples may have very smooth surfaces and it may be difficult to keep the steel point on surface without slipping. A little piece of rubber or plastic interface solve this problem. Also a short pieces of wire insulation slipped over the detector tip, which is slightly longer than the point itself will allow a steady contact and the test bar is damped very little. You will notice that it is not necessary to go far out of the centre of the bar now in order to have reproducible results.

5.1.2. Bars – Fundamental Flexural Vibration Mode – turned 90°

It is easy to measure the bar in a second direction using the flexural mode. The height (thickness) is now 40 mm and the width 10 mm.

Normally the test bar would be positioned on 2 foam strips so that the 40 mm sides are vertical, but this set-up could be rather unstable. It is easier to leave the bar positioned as before. The elastic tap is now executed sideways (in the centre) and the detector held vertically (the sensitivity dot in the direction of tapping).

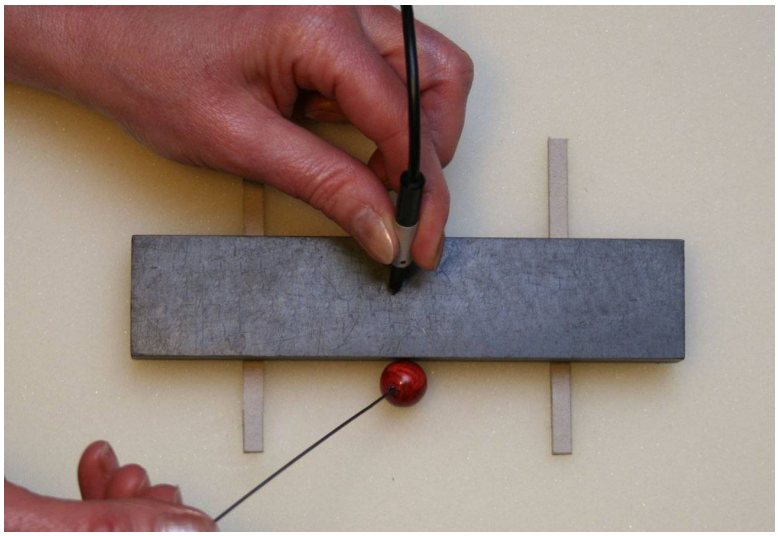


Illustration 14: Bars – Flexural Vibration 90°

5.1.3. Bars – Torsional Vibration Mode

For the torsional vibration (and possibly longitudinal, see next chapter) the support of the bar is different to the one of the flexural mode. The torsional and longitudinal modes have a nodal line in the centre. The following set-up is suggested – see illustration using 2 strips of soft foam.

This set-up allows the torsional vibration by definitely discouraging a flexural mode because of the supporting strips at the maximum of the flexural vibration.

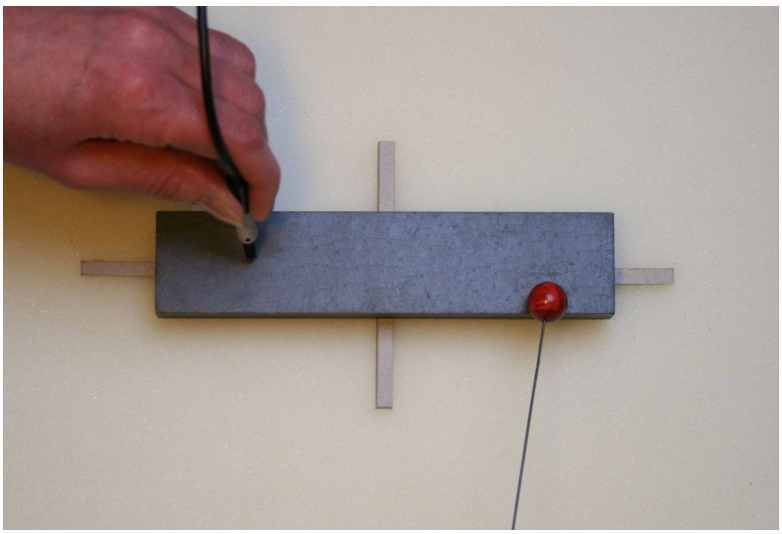


Illustration 15: Bars – Torsional Vibration

A light and elastic tap as selectively as possible into a torsional movement of the specimen is performed at one side of the bar approximately in one of the nodes of the flexural vibration (Note: to achieve the flexural vibration the object has been tapped in the centre which in fact is a node for the torsion).

The vibration can be picked up at th side of the specimen by positioning the detector tip in the node of the flexural vibration. It is suggested to depart from this point a bit towards the centre. The detector can also be held – as shown as in illustration 15 - vertically on the top of the test object. The torsional vibration is rotationally symmetrical (the flexural vibration is not, hence picking up any undesired flexural vibration is unlikely).

The user may find that this is not at all critical, but we do not want to suggest that users should be careless with the support when testing complex or highly damped objects. The measuring method follows a simple logic which should always be kept in mind when supporting and exciting the desired vibration.

5.1.4. Bars – Longitudinal Vibration Mode

Finally the longitudinal mode can be obtained as shown in illustration 16. Simply leave the supports as they are for the torsion. Position the detector in the same spot as for the torsion, but hold the dot towards the end of the sample (direction of longitudinal vibration). Do not use a plastic tip - at expected higher frequencies the transmission of the signal may become inefficient.

For the excitation use a very hard ball (steel ball about 1/4 inch (~ 6 mm) at the end of a flexible stem). Light and elastic tapping should give a highly reproducible measurement.

Remember, the ultimate criterion for correct measurements is: never accept or use any readings which cannot be reproduced easily.

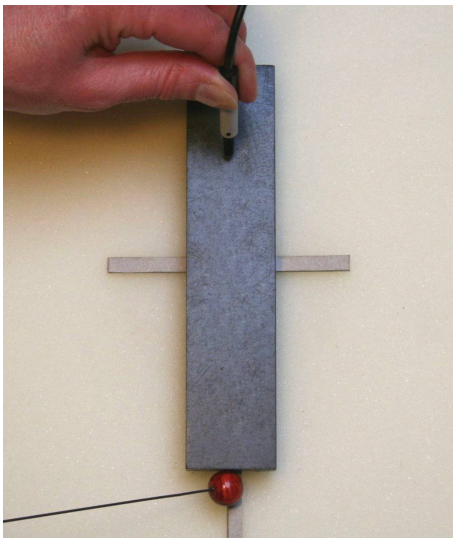


Illustration 16: Bars – Longitudinal

5.2. Cylinders

In general everything that is explained under Bar Shaped Samples shall apply to cylindrical rods (see chapter 5.1 page 21).

5.3. Discs

Disc shaped samples are very easy to measure, elastic materials constants can easily be obtained. For calculation of Young's modulus, G-modulus and Poisson Ratio, discs can be excited in 2 different modes. For very easy measurements and calculations on disc shaped samples, if possible, select a diameter to thickness ratio of 3:1 and higher. However, other ratios are possible too.

5.3.1. Discs – Torsional Vibration Mode

The torsional vibration is demonstrated in illustration 17:

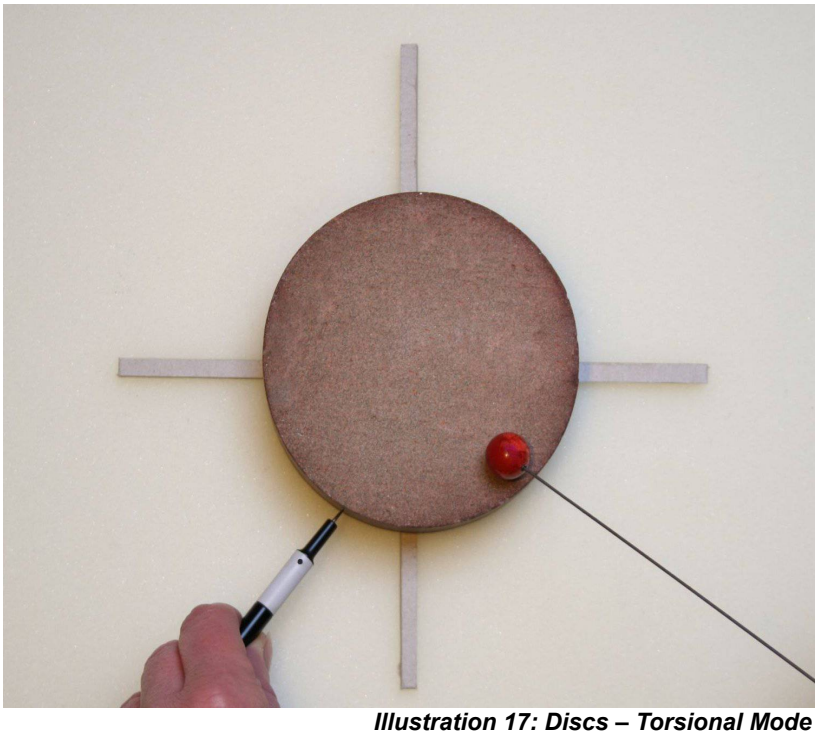


Illustration 17: Discs – Torsional Mode

Tapping on the surface of the disc, near the rim, causes a point of maximum vibration in that area. The resulting standing wave will create another maximum (same amplitude, same phase) at 180°. Two additional maxima (same amplitude, opposite phase) are created at 90° and 270°. Two perpendicular nodal diameters are created at 45° relative to the point of impact. The discs support in 4 points must be positioned along these nodal lines.

The point of impact should be selected in the middle between two nodal lines at the rim or at some smaller or larger angle, but not in an of the nodal lines. Again a plastic tip might help to improve a non-slipping contact of the piezoelectric detector.

5.3.2. Discs – Flexural Vibration Mode

The impact impulse creates a maximum amplitude in the centre of the disc, the rim will vibrate 180° offset. A nodal circle is located at 0.681 x R (radius) from the centre. A support of the discs ideally is placed along this ring – for instance 4 small rubber balls, pieces of foam etc...

The detector may be held anywhere on the periphery.

Please note: The nodal diameters of the torsion and the nodal circle of the flexure do intersect. Therefore, we have 4 points where the disc can be supported allowing the excitation of both vibration modes without changing the support.

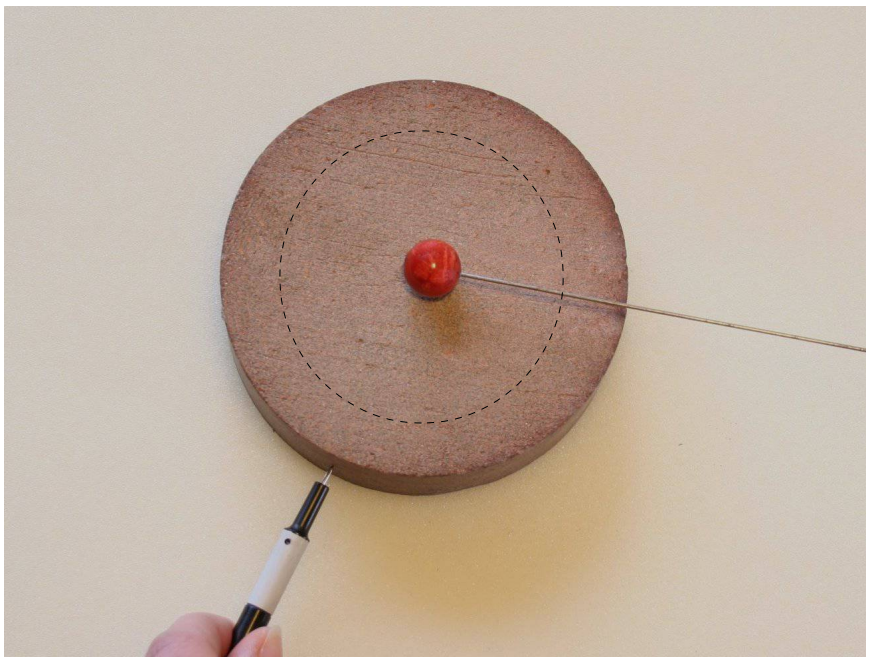


Illustration 18: Discs - Flexural Mode

5.3.3. Grinding Wheels

The fundamental vibration mode of a grinding wheel is identical to the torsional vibration mode of a disc shaped sample. This means that a grinding wheel will vibrate with maximum intensity along two diameters crossing at right angles.

The support for the fundamental vibration mode is as follows: Small to medium sized grinding wheels are normally placed on 4 (or just 2 long ones) rubber strips with a 90° angle see illustration 17 page 24. The grinding wheel should be lightly tapped near the rim on a point midway between two supports. In doing so a torsional mode is excited between the supports.

The intensity of the tap is not at all critical and correct results are obtained with surprisingly light taps as well as with fierce strikes. It is good practice to adapt the size of the tapping device and the intensity of the strike to the size of the grinding wheel under test. It is important, however, that the tapping is elastic, i.e. the tapping device must not remain in contact with the surface of the wheel to allow it to vibrate freely. Screwdrivers with plastic handles can be very appropriate tapping devices because of their elasticity. They are obtainable in most various sizes.

Large and heavy wheels may be left standing upright on the floor. The supporting point at the floor (we may define as 0° for this purpose) cannot vibrate freely. This determines the other nodal points each at 90°, 180° and 270°. Hence the tapping point can be at 45°, 135°, 225°, and 315°.

The signal is picked up by holding the point of the piezodetector against the rim of the grinding wheel so as to point the detector towards the centre. Tapping the wheel at 45° or the other points – (see previous paragraph) - will excite the desired torsional vibration. The best position for the

detector is in a point of 90° away from the point of impact, either way. Undesirable movements of the wheel about the lateral axis make the 180° from the point of impact point less favourable. The detector must be held still until the result lights up on the display panel.

Grinding wheels too thin to stand up may be hung on a support rod. Again the point of impact and signal pick-up are chosen at 45° from the supporting point.

When the detector is brought in to contact with the grinding wheel a meaningless number will be displayed on the instrument. After 1 second this is cleared automatically and the proper measurement can be initiated.

It is suggested to tap the grinding wheel 2 or 3 times in succession in order to ensure that the measurement is being carried out correctly and the values are reproducible. For properly performed measurements, the variation of successive readings on one test object and its same vibration should not exceed 1%.

5.3.4. Thick Grinding Wheels

Grinding wheels with a larger inner diameter that look like short cylinders are called “thick grinding wheels”.

Thick grinding wheels are positioned to stand upright, but instead of tapping on the flat side, they are tapped on the outer diameter under a 45° angle of the 90° diameter. The vibration is then picked up in the same position on the other half of the wheel. You will note that the detector is held against the flat side of the wheel and the dot on the detector is facing outward. The vibration pattern is called radial mode.

Note: The same technique can be applied to cup wheels and tubes.

5.4. Notes to the Calculation of Material Constants

Together with a Grindo*Sonic* the program WINEMOD of J.W.Lemmens N.V. for the calculation of elastic material constants is supplied. The program is described in chapter 6 page 27 ff.

The program and formulas are based on publications from standards committees and universities about Young's modulus, G modulus and Poisson ratio. There are different formulas for different shapes and different material classes such as concrete, ceramics, wood etc. - please refer to the appropriate standards and publications.

Although every care has been taken to implement such formulas, no responsibility or liability can be accepted by J. W Lemmens N.V. for any damages resulting from the use of the proposed formulas.

6. WINEMOD - Version 2.05

6.1. Introduction

WINEMOD is a program for Windows PCs to calculate elastic material constant such as Young's modulus, G modulus and Poisson ratio. To calculate the constants the entry of dimension, mass and the Grindo*Sonic* value are required.

WINEMOD is divided in to 2 parts:

1) **ABREMOD** Calculation of Young's modulus for **grinding wheels and honing stones**
2) **GENEMOD** Calculation of Young's modulus for **bars, cylinder and discs**

The formulas are for homogeneous and isotropic materials. J.W. Lmemens N.V. is not responsible for the accurateness of the formulas which have been developed by standards committees and universities.

6.2. Installation of WINEMOD

6.2.1. System requirements

WINEMOD has been tested and is suitable for Windows 95 to Windows 7.

6.2.2. Installation

WINEMOD (includes ABREMOD and GENEMDO) is supplied on CD or USB stick. It can also be downloaded. For this purpose please contact J.W. Lemmens N.V.

For the installation (unzip if downloaded and) run setup.exe in the directory WINEMOD.

6.3. ABREMOD

To start the program ABREMOD go to Windows <Start>, <Programs>, <WINEMOD> and click on ABREMOD. Alternatively execute the file ABREMOD.exe in the respective WINEMOD directory.

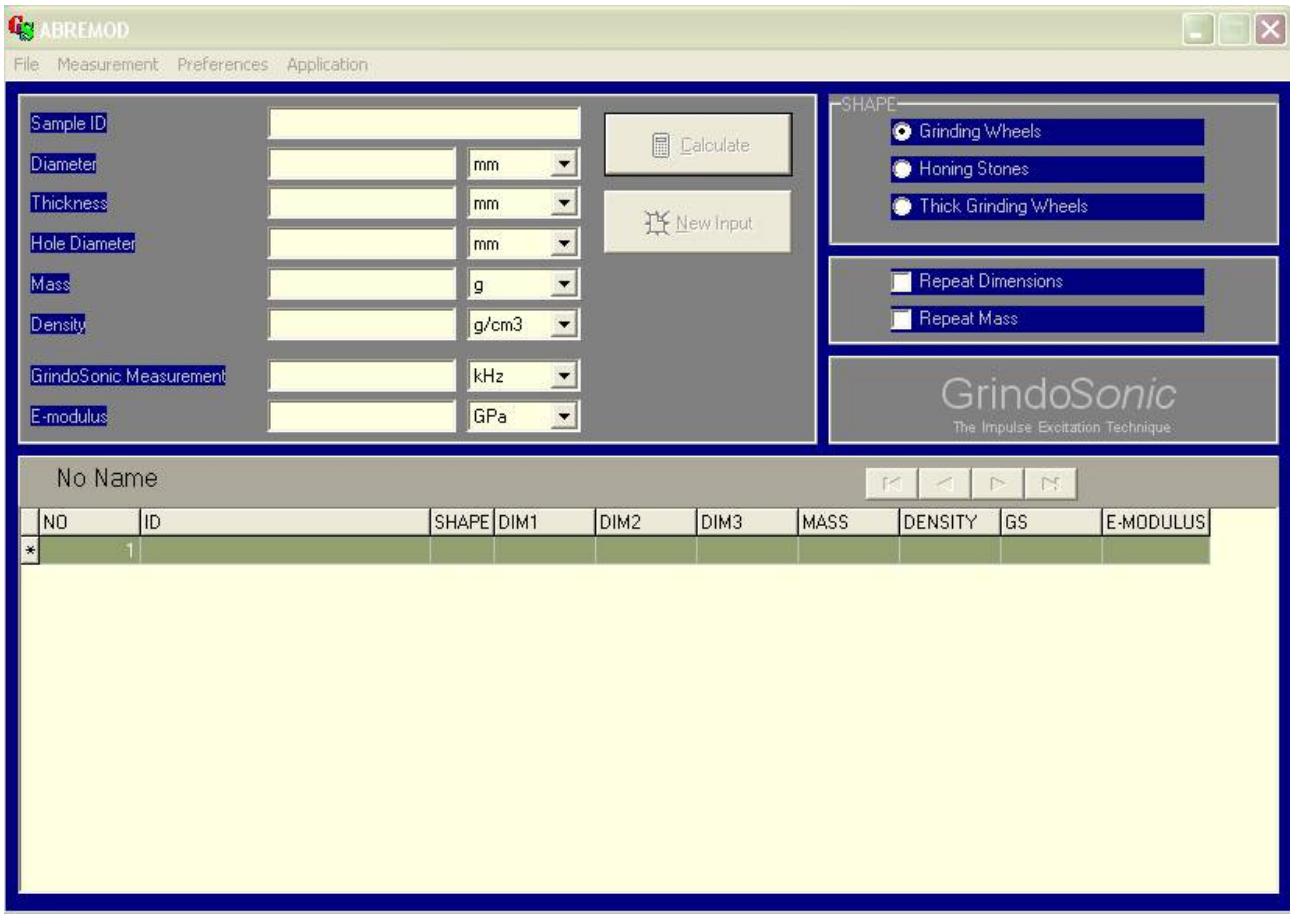


Illustration 19: Start Screen ABREMOD

The program is easy and intuitive to use. The start screen is divided in to 3 areas:

1. **Top right** (1) = Selection of the type of grinding discs with the following options:

   - **Grinding Wheels (GW)**
   - **Honing Stones (HS)**
   - **Thick Grinding Wheels (TGW)**

   Note: For the selection of disc type also see ABREMOD Formulas page 35.

   Tick the boxes below the shape field if entered dimensions and/or weight of the next samples are the same and shall be repeated.

2. The **top left** (2) area is for entering test object specific data:

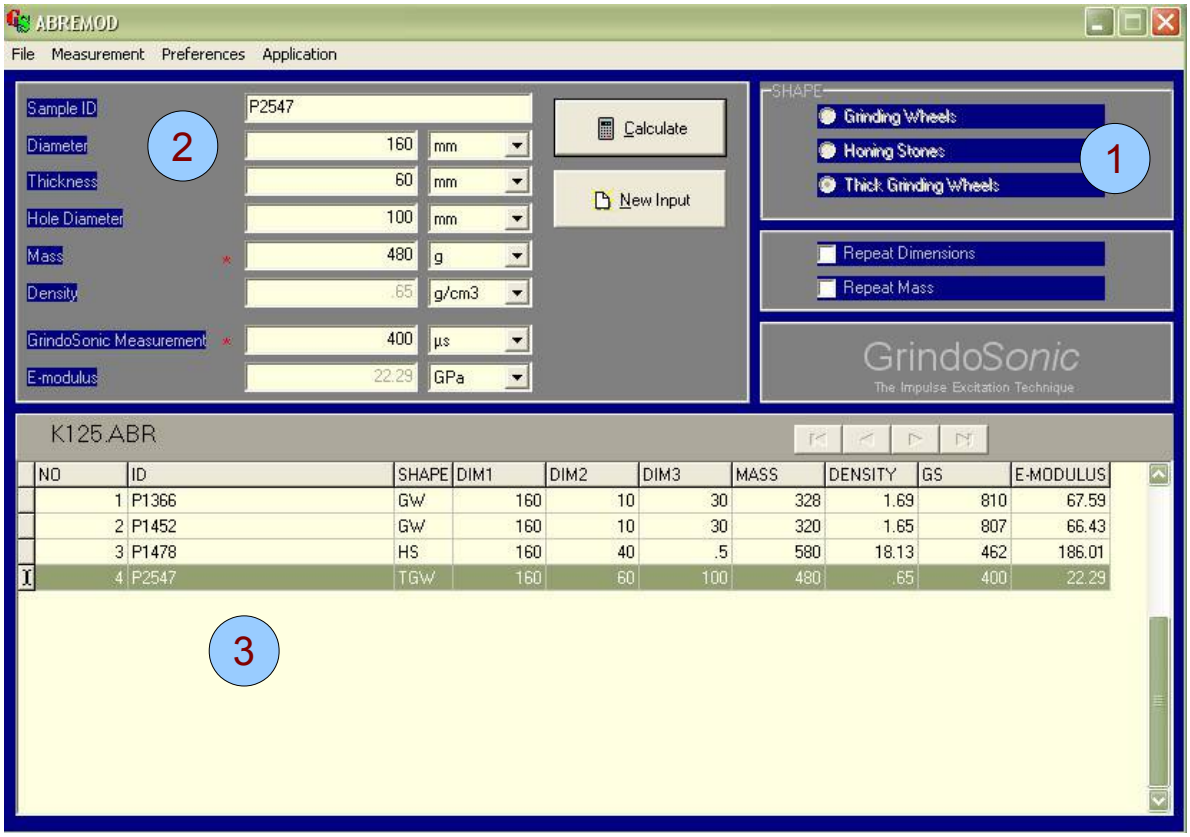
- Enter Sample ID		**(ID)**
- Enter disc diameter		**(ABM1)**
- Enter disc thickness		**(ABM2)**
- Enter inner hole diameter		**(ABM3)**
- either	**Enter mass** (calculation of density)	**(Mass)**
or	**Enter density** (calculation of mass)	**(Density)**
- either	**Enter Grindo*Sonic* Value** (calculation of E-Modulus)	**(GS)**
or	**Enter E-Modulus** (Calculation of GrindoSonic Frequency)	**(E-Modulus)**

For entering data make sure that the correct dimension unit has been selected, e.g. for the Grindo*Sonic* value <kHz>, <µs> or >Reading>, e.g. for the mass <g>, <kg>, <oz>.

Different object types and dimensions can be selected in one file.

After all relevant data have been entered click on the <Calculate> button. The E-modulus results are shown and a new data set can be entered – click on <New Input>.

3. **The lower part** (3) lists entered data and results in a table format. For abbreviations see paragraph 2. on this page. Before saving the file first time the file name No Name is shown – after saving the file <FILENAME.ABR> is shown.



NO	ID	SHAPE	DIM1	DIM2	DIM3	MASS	DENSITY	GS	E-MODULUS
1	P1366	GW	160	10	30	328	1.69	810	67.59
2	P1452	GW	160	10	30	320	1.65	807	66.43
3	P1478	HS	160	40	.5	580	18.13	462	186.01
4	P2547	TGW	160	60	100	480	.65	400	22.29

Illustration 20: Start Screen with Input/Selection Fields

6.3.1. ABREMOD – Main Menu

6.3.1.1. ABREMOD Menu <File>

To open the file menu click on File or Press <Alt>+<F>.

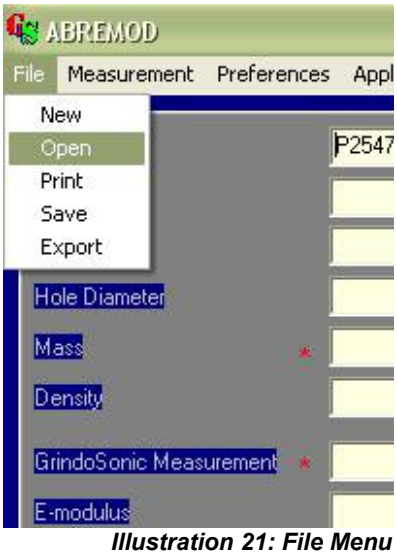


Illustration 21: File Menu

New: Use this menu function to start a new file – with the name 'No Name' appearing above the list area (3). When saving the file or when exiting the program a file name is requested. The file extension .ABR is added automatically. When starting a new file and the current file has no name, you will first be asked to save the current file before a new file is opened.

Open: Use this menu option to open an existing file. You can select from all .ABR files, double-click the chosen file. If you are currently using another file without a name, you will first be asked to save the current file before the file is opened.

Print: Use this menu option to print the current file.

Save: Use this menu option to save the current file.

Export: Use this menu option to export the file to text format (;-delimited). The text file will use the same name but with a .TXT extension. The first line of the text file is a header denominating the 18 columns.

6.3.1.2. ABREMOD Menu <Measurement>

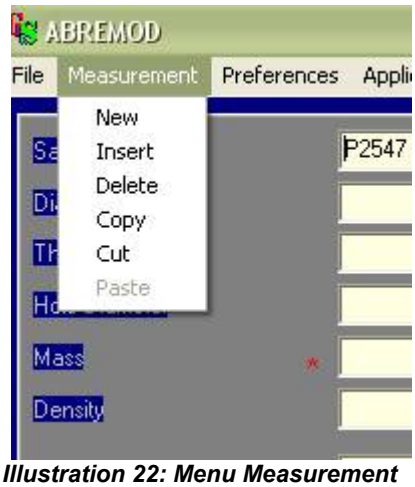


Illustration 22: Menu Measurement

New: Use this menu option to add a new measurement. This menu option is identical to clicking the <New Input> button see area (2). The new measurement record is added to the end of the measurement list.

Insert: Use this menu option to insert a new measurement. The measurement is inserted before the current measurement.

Delete: Use this menu option to delete the current measurement. The measurement is permanently removed.

Copy: Use this menu option to copy the current record. Use the Paste option to insert it at another place in the measurement list.

Cut: Use this menu option to move the current record. First remove the current record with the Cut option, then use the Paste option to insert it at another place in the measurement list.

Paste: Use this menu option to insert a 'Copied' or 'Cut' measurement at a new place in the measurement list. This option is only available after a 'Copy' or 'Cut' operation.

6.3.1.3. ABREMOD Menu <Preferences>

The Preferences menu allows the user to customize program settings.

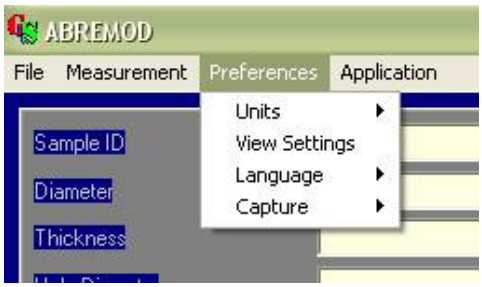


Illustration 23: Menu Preferences

Units: Use this menu option to save the current set of dimension units as the default. The program will use this set of units at start-up.

View settings: The decimal places for the units can be selected:

Dimensions (0-4 decimal places)
Density (0-5 decimal places)
Mass (0-5 decimal places)
Grindo*Sonic* value (0-5 decimal places)
Modulus (maximum 1-3 decimal places)

Language: Options are English / German / French

Capture: The Grindo*Sonic* measurement can be loaded directly to the program by using the <Capture> function via a RS232 connection. For this <Capture> has to be set to <ON>. Also the RS232 communication settings have to be aligned between computer and Grindo*Sonic* – use the menu communication settings to select:

RS232-Com Port of PC
Baud rate
Parity
Data Bits
Stop Bits

Important Note: For correct data transmission, the point <.> must be selected as the decimal separator in the Windows Regional Settings menu. In countries like Germany or others the <,> (Comma) might be selected by default. Please change accordingly in the Windows Control Panel.

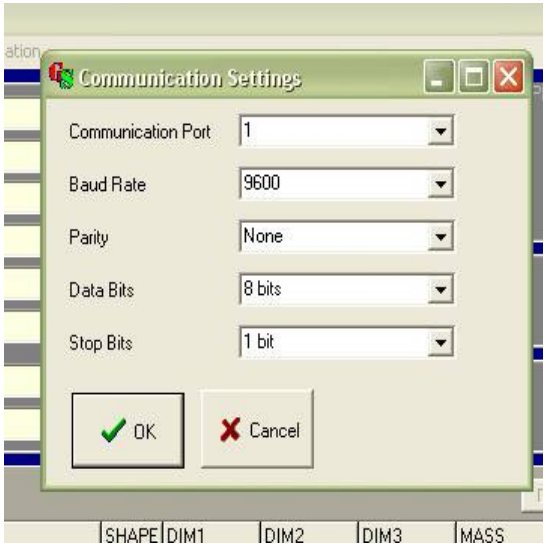


Illustration 24: RS232 Settings

6.3.1.4. ABREMOD Menu <Application>

This menu contains information about the current software revision. To quit the program use <Exit>.

6.3.2. ABREMOD List Area

The list area (3) shows all the records contained in the file. Click on a record in the list area to make that record the current one. This measurements will be displayed in the input/result area (2) and can be changed and re-calculated.

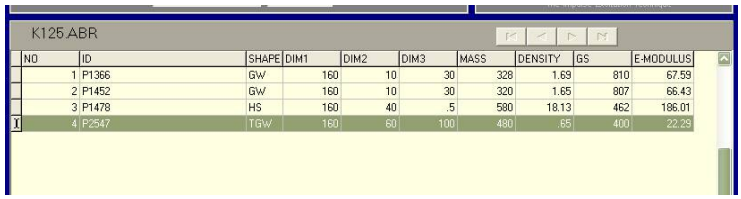


Illustration 25: List Area

6.3.3. ABREMOD The Input/Result Area

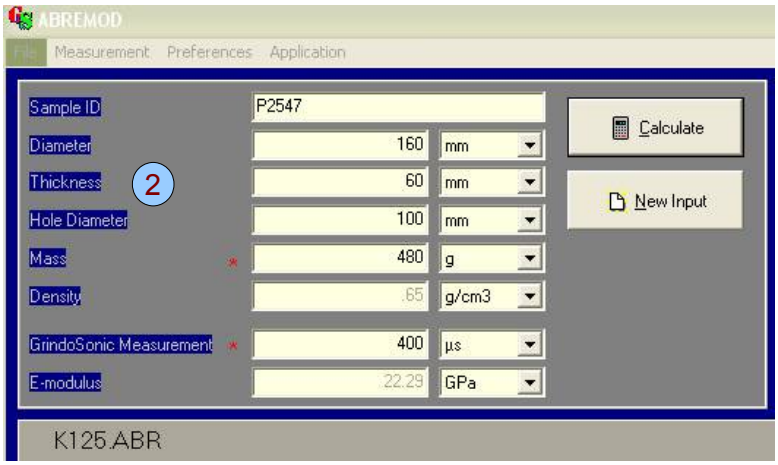


Illustration 26: Input Area

This area is for entering/editing measurements. Use the <Tab> key or the mouse to go to the next field.

When dimensions and mass have been entered the density is automatically calculated. After entering the Grindo*Sonic* value and clicking on <Calculate> the E-modulus will be calculated.

In both cases (entering mass and the Grindo*Sonic* value) one can also enter the density first (the respective mass will be calculated) or one can enter the E-modulus (to calculate the Grindo*Sonic* value. The manually entered value is marked with a small red asterisk.

6.3.4. ABREMOD - Entering a new measurement

After starting the program a new data record can be entered immediately in the edit area (2).

Alternatively <New Input> (if selectable and not light grey) can be clicked. Firstly – if not done already – the shape must be selected in area (1) .

> **Note:** For options and limits see ABREMOD Formulas page 35.

To enter data start with the sample ID (field ID). To go to the next field press the <Tab> key.

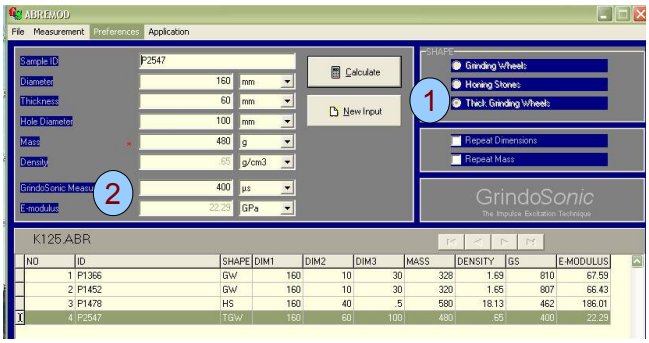


Illustration 27: Entering Data

Click on the arrows of the unit list boxes to display the available units and select accordingly. The corresponding field will be emptied to avoid any wrong entry/calculation. Use the <Preferences> – <Units> – <Set as default> menu option to save the current set of units for future use.

Either mass or density can be entered: as soon as the dimensions are entered, the mass (or density) will be calculated. The value entered manually is indicated by a red asterisk.

After entering the Grindo*Sonic* value (or a known E-modulus) the button <Calculate> can be pressed - the value entered manually is indicated by an asterisk.

The button <Calculate> can only be selected when all necessary date have been entered:

- Sample ID
- all dimensions
- either mass or density
- either Grindo*Sonic* value or E-modulus

Note: If dimensions and weight of the samples remain the same for the calculations the values do not need to be entered every time: by clicking the tick boxes <Repeat Dimension> and/or <Repeat Mass> in area (1) the value can be taken over for the next record input.

6.3.5. ABREMOD - Printing a measurement report

Use the <File> <Print> menu option to print a report of all entered records.

6.3.6. ABREMOD Formulas

6.3.6.1. Formulas Grinding Wheels

Source:

„New Formulas improve E-Modulus Calculations“, A. Decneut, Report CRIF MC34, November 1970

Limits:

b/D > 0,3 (b = Thickness, D = Disc diameter)
d/D < 0,71 (d = Inner hole diameter, D = Disc diameter)

6.3.6.2. Formulas Thick Grinding Wheels

Source:

„New Formulas Improve E-Modulus Calculations“, A. Decneut, Report CRIF MC34, November 1970

Limits:

0,67 <= D/b <= 3,3 (b = Thickness, D = Disc diameter)
0,3 <= d/D (d = Inner hole diameter, D = Disc diameter)

6.3.6.3. Formulas Honing Stones

Source:

„New Formulas Improve E-Modulus Calculations“, A. Decneut, Report CRIF MC34, November 1970

Limits:

l/h > 3 (l = Length, h = Height)

6.3.7. ABREMOD Format of List and Export File

The exported file is a text file (ending with .txt) and with the following header information for the respective columns:

	Description	Column name	Options
1	Sequential number	No	--
2	Test object ID	ID	--
3	Shape of test object	Shape	- GW Grinding Wheel - HS Honing Stone - TGW Thick Grinding Wheel
4	Disc diameter	DIM1	Unit dimension DIM1
5	Thickness of disc	DIM2	Unit dimension DIM2
6	Inner hole diameter	DIM3	Unit dimension DIM3
7	Weight of disc	MASS	Unit dimension Mass
8	Density of disc	DEMSITY	Unit dimension Density
9	Identification what has been entered (mass or density)	M/D = Input	M = Input of Mass D = Input of Density
10	Grindo*Sonic* value	GS (Grindo*Sonic*)	Unit dimension GS
	E-modulus	E-modulus	Unit dimension E-modulus
11	Identification what has been entered (Grindo*Sonic* value or E-modulus)	D/R calculation	D = E-modulus calculated (input of GS value) R = GS value calculated (input of E-modulus)

6.4. GENEMOD

To start the program GENEMOD go to Windows <Start>, <Programs>, <WINEMOD> and click on GENEMOD. Alternatively execute the file GENEMOD.exe in the respective WINEMOD directory. The program is easy and intuitive to use. The start screen is divided in to 3 areas:

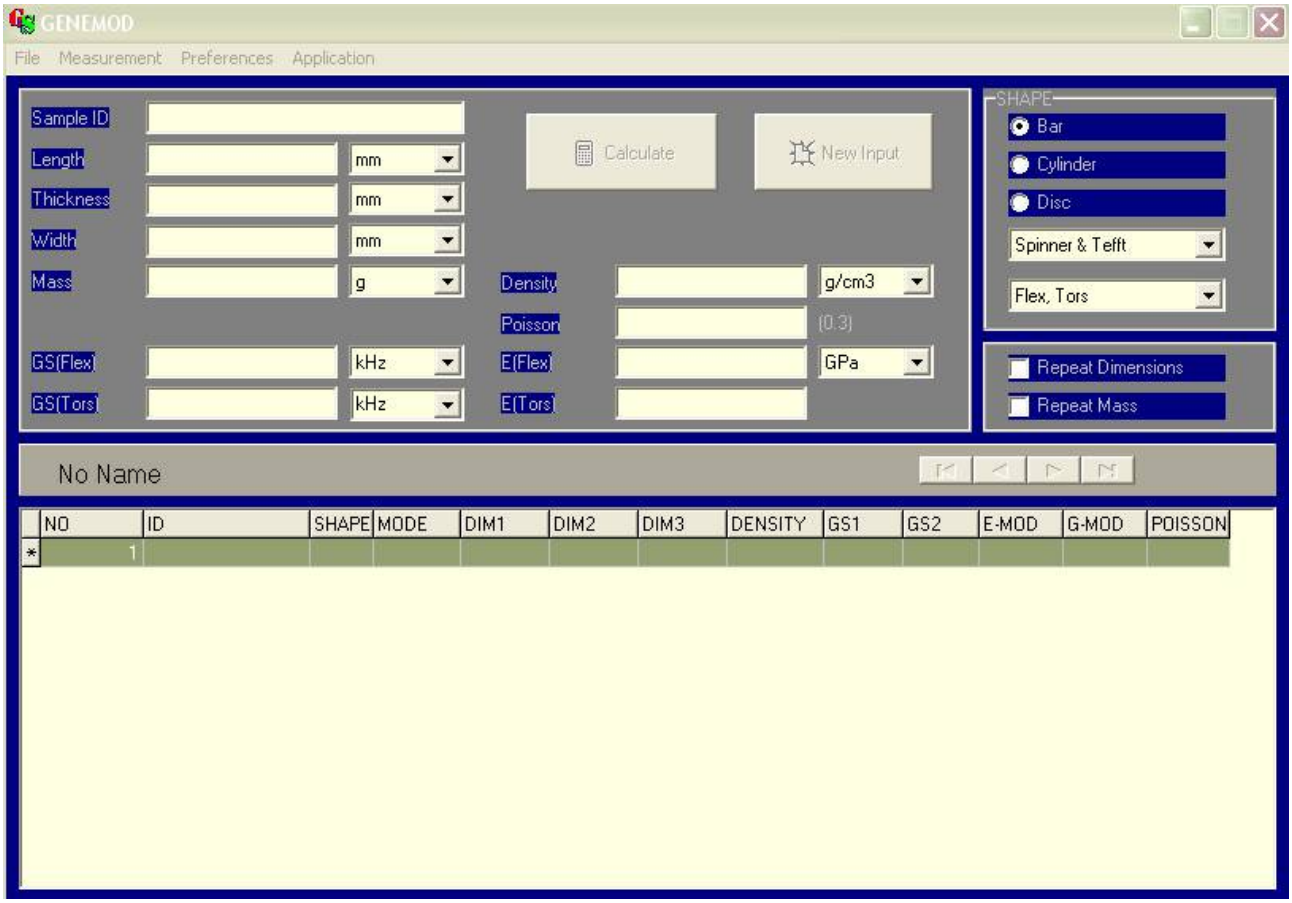


Illustration 28: Start screen GENEMOD

1. **Top right** (1): the test object shape can be selected with the following options:

   - **Bar** **(BAR)**
   - **Cylinder** **(CYL)**
   - **Disc** **(DSC)**

   In the two pull down options below in the FORM area the formulas and vibration modes can be chosen – depending on the selected formulas.

   Tick the boxes below the shape field if entered dimensions and/or weight of the next samples are the same and shall be repeated.

   Note: For the selection of formulas see GENEMOD Formulas page 45.

2. **The top left area** (2) is to enter test object specific data:

Bars:

- Enter sample ID		**(ID)**
- Enter length		**(ABM1)**
- Enter thickness		**(ABM2)**
- Enter width		**(ABM3)**
- either	**Enter mass** (calculation of density)	**(Mass)**
or	**Enter density** (calculation of mass)	**(Density)**
- **Enter Grindo*Sonic* value FLEX or LONG** (+)		**(GS1)**
- Enter Grindo*Sonic* value TORS or 2. harm. FLEX (+)		**(GS2)**
- Calculation Poisson ratio (++)		**(Poisson)**
- **Calculation E-modulus**		**(E-modulus)**
- Calculation G-modulus		**(G-modulus)**

For cylinders:

- Enter sample ID		**(ID)**
- Enter length		**(ABM1)**
- Enter diameter		**(ABM2)**
- either	**Enter mass** (calculation of density)	**(Mass)**
or	**Enter density** (calculation of mass)	**(Density)**
- Enter Grindo*Sonic* value FLEX or LONG (+)		**(GS1)**
- Enter Grindo*Sonic* value TORS or 2. harm. FLEX (+)		**(GS2)**
- Calculation Poisson ratio (++)		**(Poisson)**
- Calculation E-modulus		**(E-modulus)**
- Calculation G-modulus		**(G-modulus)**

For discs:

- Enter sample ID		**(ID)**
- Enter diameter		**(ABM1)**
- Enter thickness		**(ABM2)**
- either	**Enter mass** (calculation density)	**(Mass)**
or	**Enter density** (calculation mass)	**(Density)**
- Enter Grindo*Sonic* value FLEX (+++)		**(GS1)**
- Enter Grindo*Sonic* value TORS (+++)		**(GS2)**
- Calculation Poisson ratio (++)		**(Poisson)**
- Calculation E-modulus		**(E-modulus)**
- Calculation G-modulus		**(G-modulus)**

(+) The combination of different vibration modes have to be selected in area 1 just below the shape selection.

(++) If only one Grindo*Sonic* value has been measured and entered for the calculation a default Poisson ratio is used (and displayed to the right of the field). This default Poisson can be changed in the menu <Preferences> and <Poisson>. If e.g. a flexural and torsional Grindo*Sonic* value can be measured and entered it is possible to calculate Poisson iteratively (within limitations). This is indicated with a light grey „Calculated“ right next to the field.

(+++) The formulas for discs are based on “Glandus” with torsional and flexural modes. Both Grindo*Sonic* measurements are necessary for the calculation.

For entering data make sure that the correct dimension unit has been selected, e.g. for the Grindo*Sonic* value <kHz>, <µs> or >Reading>, e.g. for the mass <g>, <kg>, <oz>.

Different object types and dimensions can be selected and mixed in one file.

When all relevant data have been entered click on the <Calculate>. The calculated results are shown and a new data set can be entered – click on <New Input> or press <Alt>+ <N>.

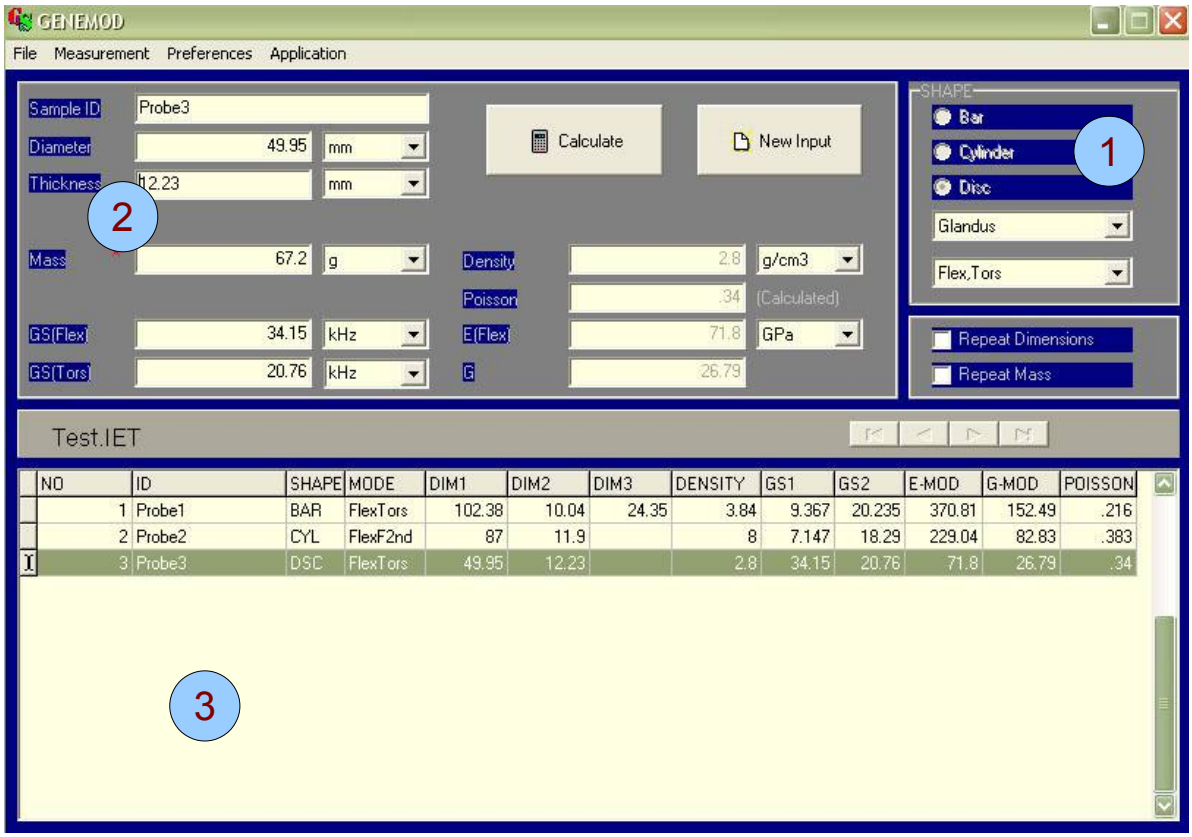


Illustration 29: Main Screen - Inputs

3. **The lower part** (3) lists the entered data and results in a table format. For abbreviations see paragraph 2 on the previous page. Before saving the file first time “No Name” is shown above the list – after saving the file, the name with the ending FILENAME.IET is displayed.

6.4.1. GENEMOD – Main Menu

6.4.1.1. GENEMOD <File> Menu

To open the file menu, click on File or Press <Alt>+<D>.

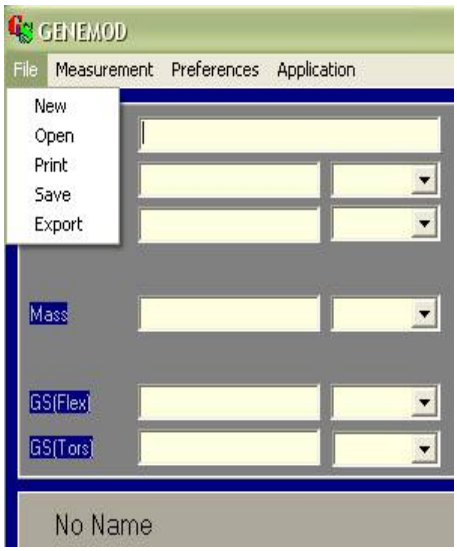


Illustration 30: GENEMOD File Menu

New: Use this menu function to start a new file – with the name 'No Name' appearing above the list area (3). When saving the file or when exiting the program a file name is requested. The file extension .IET is added automatically. When starting a new file and the current file has no name, you will first be asked to save the current file before a new file is opened.

Open: Use this menu option to open an existing file. You can select from all .IET files, double-click the chosen file. If you are currently using another file without a name, you will first be asked to save the current file before the file is opened.

Print: Use this menu option to print the current file.

Save: Use this menu option to save the current file.

Export: Use this menu option to export the file to text format (;-delimited). The text file will use the same name but with a .TXT extension. The first line of the text file is a header denominating the 18 columns.

6.4.1.2. GENEMOD Menu <Measurement>

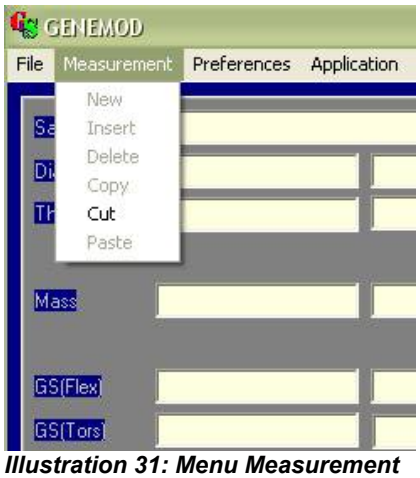


Illustration 31: Menu Measurement

New: Use this menu option to add a new measurement. This menu option is identical to clicking the <New Input> button see area (2). The new record is added to the end of the measurement list.

Insert: Use this menu option to insert a new measurement. The measurement is inserted before the current measurement.

Delete: Use this menu option to delete the current measurement. The measurement is permanently removed.

Copy: Use this menu option to copy the current record. Use the Paste option to insert it at another place in the measurement list.

Cut: Use this menu option to move the current record. First remove the current record with the Cut option, then use the Paste option to insert it at another place in the measurement list.

Paste: Use this menu option to insert a 'Copied' or 'Cut' measurement at a new place in the measurement list. This option is only available after a 'Copy' or 'Cut' operation.

6.4.1.3. GENEMOD Menu <Preferences>

The Preferences menu allows the user to customize the program settings.

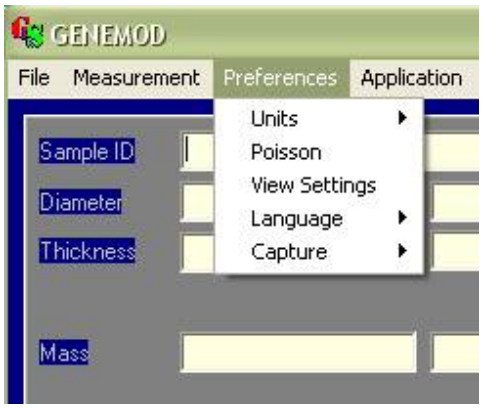


Illustration 32: Menu Preferences

Units: Use this menu option to save the current set of dimension units as the default. The program will use this set of units at start-up.

View settings: The decimal places for the units can be selected:

Dimensions (0-4 decimal places)
Density (0-5 decimal places)
Mass (0-5 decimal places)
Grindo*Sonic* value (0-5 decimal places)
Modulus (maximum 1-3 decimal places)

Language: Options are English / German / French

Capture: The Grindo*Sonic* measurements can be loaded directly to the program by using the <Capture> function via a RS232 connection. For this <Capture> has to be set to <ON>. Also the RS232 communication settings have to be aligned between computer and Grindo*Sonic* – use the menu <Communication settings> to select:

RS232-Com Port of PC
Baud rate
Parity
Data Bits
Stop Bits

Important Note: For correct data transmission, the point <.> must be selected as the decimal separator in the Windows Regional Settings menu. In countries like Germany or others the <,> (Comma) might be selected by default. Please change accordingly in the Windows Control Panel.

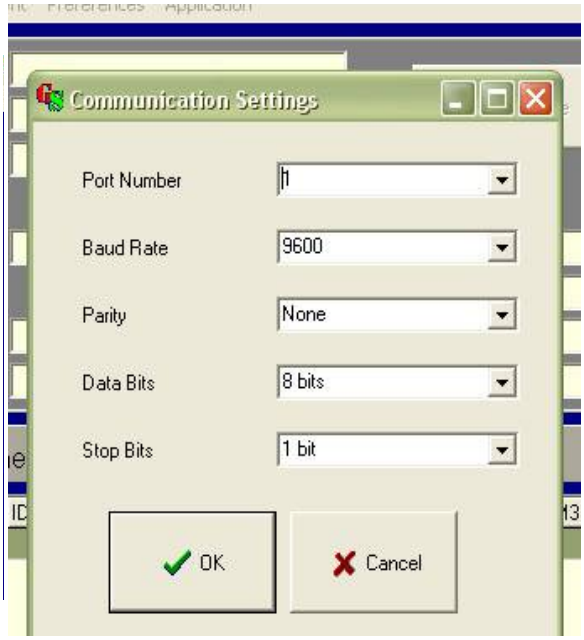


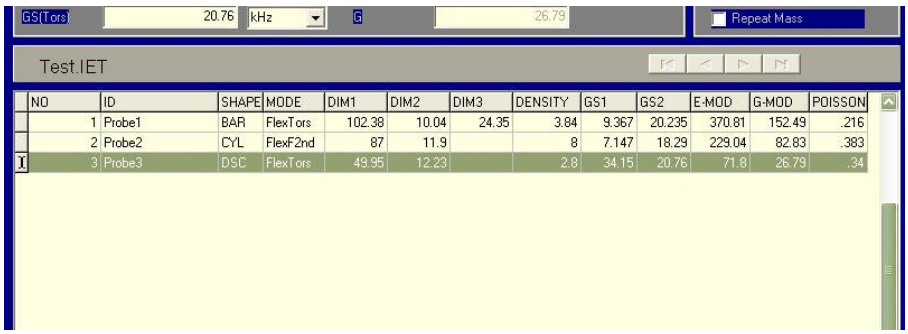
Illustration 34: RS232 Settings

6.4.1.4. GENEMOD Menu <Application>

This menu contains information about the current software revision. To quit the program use <Exit>.

6.4.2. GENEMOD List Area

The list area (3) shows all the entered records contained in the file. Click on a measurement in the list area to make that record the current one. This measurement will be displayed in the input/result area (2) and can be changed and calculated again.



NO	ID	SHAPE	MODE	DIM1	DIM2	DIM3	DENSITY	GS1	GS2	E-MOD	G-MOD	POISSON
1	Probe1	BAR	FlexTors	102.38	10.04	24.35	3.84	9.367	20.235	370.81	152.49	.216
2	Probe2	CYL	FlexF2nd	87	11.9		8	7.147	18.29	229.04	82.83	.383
3	Probe3	DSC	FlexTors	49.95	12.23		2.8	34.15	20.76	71.8	26.79	.34

Illustration 35: GENEMOD List Area

6.4.3. GENEMOD The Input/Result Area

This area is for entering / editing measurements. Use the <Tab> key or the mouse to go to the next field.

When dimensions and mass have been entered the density is automatically calculated. After entering the Grindo*Sonic* value and clicking on <Calculate> the E-modulus will be calculated.

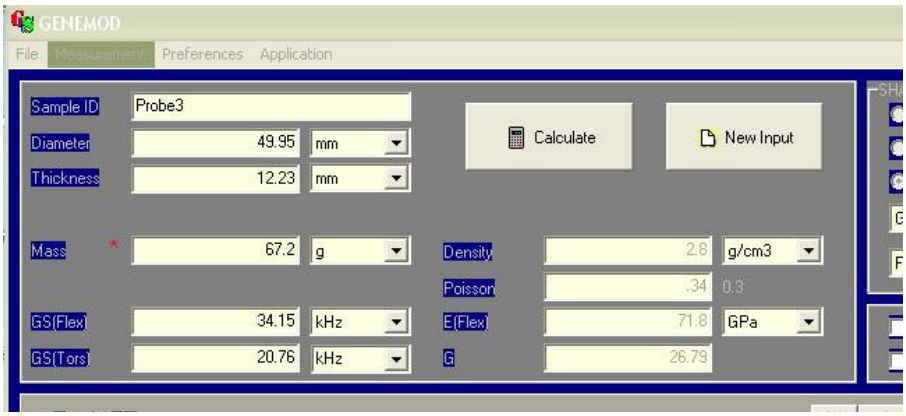


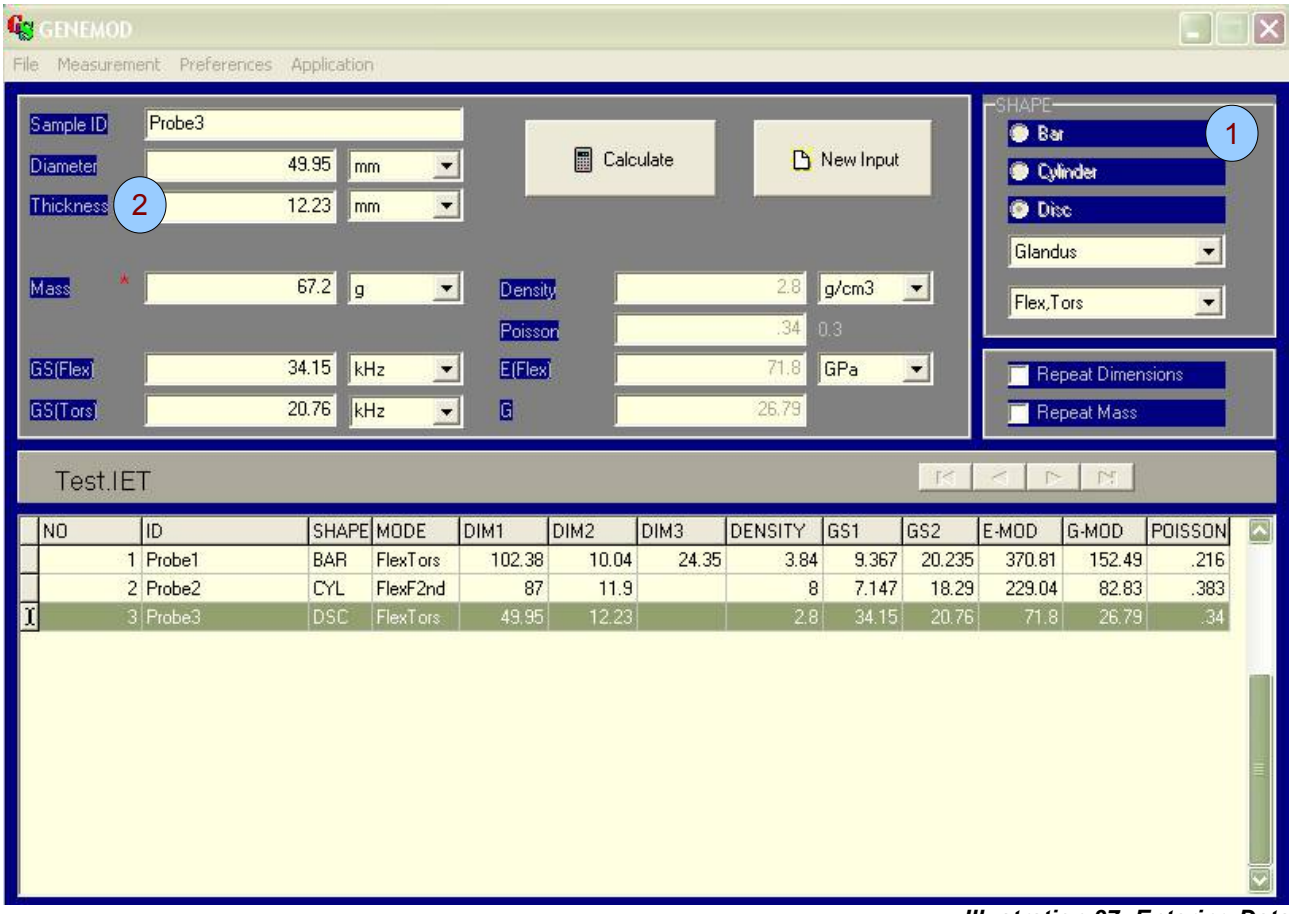
Illustration 36: GENEMOD Input Area

It is possible to enter the density first. In this case the mass will be calculated by the program. The manually entered value is marked with a red asterisk

6.4.4. GENEMOD – Entering a new measurement

After starting the program a new data record can be entered immediately in the edit area (2) .

Alternatively <New Input> (if selectable and not light grey) can be clicked. Firstly – if not done already – the shape and the formulas must be selected in area (1).



NO	ID	SHAPE	MODE	DIM1	DIM2	DIM3	DENSITY	GS1	GS2	E-MOD	G-MOD	POISSON
1	Probe1	BAR	FlexTors	102.38	10.04	24.35	3.84	9.367	20.235	370.81	152.49	.216
2	Probe2	CYL	FlexF2nd	87	11.9		8	7.147	18.29	229.04	82.83	.383
3	Probe3	DSC	FlexTors	49.95	12.23		2.8	34.15	20.76	71.8	26.79	.34

Illustration 37: Entering Data

Note: For options and limits see chapter GENEMOD Formulas page 45.

Illustration 38: Shape

To enter data begin with the sample ID (field ID). To go to the next field press the <Tab> key.

Click on the arrows of the unit list boxes to display the available units. Click on the desired unit. The corresponding field will be emptied to avoid any wrong entry. Use the <Preferences> – <Units> – <Set as default> menu option to save the current set of units for future use.

Either mass or density can be entered: as soon as the dimensions are entered, the mass or density will be calculated. The value entered manually is indicated by a red asterisk.

After entering the Grindo*Sonic* value (or a known E-modulus) the button <Calculate> can be pressed, the value entered manually is indicated by an asterisk.

The button <Calculate> can only be selected when all necessary date have been made available:

- Sample ID
- all dimensions
- either mass or density
- either Grindo*Sonic* value or E-modulus

Note: If dimensions and weight of the samples remain the same for the calculations the values do not need to be entered every time: by clicking the tick boxes <Repeat Dimension> and/or <Repeat Mass> in area (1) the value can be taken over for the next record input.

6.4.5. GENEMOD – Printing a measurement report

Use the <File> <Print> menu option to print a report of all entered records.

6.4.6. GENEMOD Formulas

6.4.6.1. Bars – Formulas Spinner&Tefft

Source:

„A method for determining mechanical resonance frequencies and for calculating elastic moduli from these frequencies“, S. Spinner and W.E. Tefft, Proceeding ASTM Vol 61, 1961, page 1229.

Limits:

Flexural vibration:

The calculation is very accurate for long, thin samples, but the error increases with increasing height to length ratio. When no torsional measurement has been supplied the default Poisson ratio is used. When the torsional measurement has been supplied Poisson ratio can be calculated. However, if the iteration runs out of range the default Poisson ratio is used.

Longitudinal vibration:

The calculation is very accurate if the cross-section does not deviate too much from its square value. When no torsional measurement has been supplied the default Poisson ratio is used. When the torsional measurement has been supplied Poisson ratio can be calculated. However, if the iteration runs out of range the default Poisson ratio is used.

Additionally the following restrictions to the dimensions are applicable:

$0.00 <= (2A^2+B^2/3)^{1/2} / (2L) <= 0.50$

Torsional Vibration:

The calculation should be exact within 0.2% for:

$B/L <= 0.3$ and $B/A <= 10$

6.4.6.2. Bars – Formulas NBN B15 230

Source:

„Essais Non-destructifs, Mesure de la frèquence de Résonance“, l'Institut Belge de la Normalisation, 1976.

Limits:

For accurate results the length of the object should be at least four times the height.

Similar to the Spinner & Tefft calculation – see page 45, Poisson Ratio is calculated through iteration if the flexural and torsional Grindo*Sonic* measurement has been provided. The calculation will be stopped when Poisson ratio exits the valid range of 0.00 to 0.50. In this case the default setting for Poisson Ratio is used.

6.4.6.3. Bars – Formulas DIN 1048

Source:

„Prüfung von Beton, Empfehlungen und Hinweise als Ergänzung zu DIN 1048“, Norbert Bunke, Germany,1991.

Limits:

For accurate results the length of the object should be at least 1.5 times the height or width.

Similar to the Spinner & Tefft calculation – see page 45, Poisson Ratio is calculated through iteration if the flexural and torsional Grindo*Sonic* measurement has been provided. The calculation will be stopped when Poisson ratio exits the valid range of 0.00 to 0.50. In this case the default setting for Poisson Ratio is used.

6.4.6.4. Bars – Formulas ASTM E1876 / C1259

Source:

„Standard Test Method for Dynamic's Young's Modulus and Poisson's Ratio by Impulse Excitation of Vibration“,ASTM Standard E1876-99.

„Standard Test Method for Dynamic's Young's Modulus and Poisson's Ratio for Advanced Ceramics by Impulse Excitation of Vibration“,ASTM Standard C1259-94.

6.4.6.5. Cylinders – Formulas Spinner&Tefft

Source:

„A method for determining mechanical resonance frequencies and for calculating elastic moduli from these frequencies“, S. Spinner and W.E. Tefft, Proceedings ASTM Vol 61, 1961, page 1229.

Flexural:

When no torsional measurement has been supplied, the default Poisson ratio is used. When the torsional and the flexural measurement has been provided supplied Poisson ratio can be calculated. However, if the iteration runs out of the valid range the default Poisson ratio is used.

The diameter to length ratio should be between 0.00 and 0.60.

Longitudinal:

When no torsional measurement has been supplied, the default Poisson ratio is used. When the torsional and the flexural measurement has been provided supplied Poisson ratio can be calculated. However, if the iteration runs out of the valid range the default Poisson ratio is used.

The ratio <diameter to 2 x length> should be between 0.00 and 0.50.

6.4.6.6. Cylinders – Formulas NBN B15 230

Source:

„Essais Non-destructifs, Mesure de la frèquence de Résonance“, l'Institut Belge de la Normalisation, 1976.

Limits:

For accurate results, the length of the object should be at least be four times the height of the object.

Similar to the Spinner & Tefft calculation – see page 45, Poisson Ratio is calculated through iteration if the flexural and torsional Grindo*Sonic* measurement has been provided. The calculation will be stopped when Poisson ratio exits the valid range of 0.00 to 0.50. In this case the default setting for Poisson Ratio is used.

6.4.6.7. Cylinders – Formulas DIN 1048

Source:

„Prüfung von Beton, Empfehlungen und Hinweise als Ergänzung zu DIN 1048“, Norbert Bunke, 1991.

Limits:

For accurate results the length of the object should be at least 1.5 times the height or width.

Similar to the Spinner & Tefft calculation – see page 45, Poisson Ratio is calculated through iteration if the flexural and torsional Grindo*Sonic* measurement has been provided. The calculation will be stopped when Poisson ratio exits the valid range of 0.00 to 0.50. In this case the default setting for Poisson Ratio is used.

6.4.6.8. Cylinders – Formulas ASTM E1876 / C1259

Source:

„Standard Test Method for Dynamic's Young's Modulus and Poisson Ratio by Impulse Excitation of Vibration“,ASTM Standard E1876-99.

„Standard Test Method for Dynamic's Young's Modulus and Poisson Ratio for Advanced Ceramics by Impulse Excitation of Vibration“,ASTM Standard C1259-94.

6.4.6.9. Discs – Formulas Glandus

Source:

„Rupture fragile et résistance aux chocs thermiques de céramics à usages méchaniques“, J.C Glandus, Thèse présentée à l'université de Limogés .

Limits:

The calculation method of Glandus is based on the knowledge of both the flexural and the torsional Grindo*Sonic* measurement. It is necessary to enter both values.

Additionally the following limits are applicable:

1.350 <= GS(FLEX) / GS(TORS) <= 1.900
0.00 <= Height to Radius <= 0.50

6.4.7. GENEMOD Format of the Lists and Export file

The exported file is a text file (ending with .txt) and with the following header information for the respective columns:

	Description	Column name	Options
1	Sequential number	No	--
2	Test Object ID	ID	--
3	Shape of test object	Form	- GW Grinding Wheel - HS Honing Stone - TGW Thick Grinding Wheel
4	Formulas for calculation	Source	- S&T = Spinner&Tefft - 1876 = ASTME1876 or ASTMC1259 - DIN = DIN1048 - NBN = NBN B15-230
4	Length of bar / cylinder or diameter of disc	DIM1	Unit dimension DIM1
5	Thickness of bar / disc or diameter of cylinder	DIM2	Unit dimension DIM2
6	Width of bar	DIM3	Unit dimension DIM3
7	Weight	MASS	Unit dimension Mass
8	Density	DICHTE	Unit dimension Density
9	Identification what has been entered (mass or density)	M/D = Input	M = Input of Mass D = Input of Density
	Selection of vibration mode	Mode	- FlexTors (GS1=flexural, GS2=torsional) - LongTors (GS1=longitud., GS2=torsional) - Flex2ndHarm (GS1=flex., GS2= 2.Harm.)
	Grindo*Sonic* value 1	GS1	Unit dimension ofGS1
10	Grindo*Sonic* value 2	GS2	Unit dimension of GS2
	Calculated E-modulus	E-Modulus	Unit dimension of E-modulus
	Calculated G-modulus	G-Modulus	Unit dimension of G-modulus
	Poisson ratio	POISSON	
11	Identification if Poisson has been calculated or the standard value has been selected	POISSON D/C	C = Poisson calculated D = Poisson default (Preference)

7. GSData for data transmission – Version 4.00

7.1. Introduction GSData

The program GSData is a simple program for Windows (XP – 7) to directly import Grindo*Sonic* measuring values in to a PC (since Version MK5"Industrial"). The data is stored in the <;-delimited>-format (.txt file) and can be imported in to office programs such as Excel or LibreOffice for analysis. These 2 programs for instance automatically recognise the file format.

GSData requests the data from a Grindo*Sonic* instrument via the RS232 communications port. Connect Grindo*Sonic* and a PC via the supplied serial cable (with D-Sub 9way connectors). If the PC or laptop does not have a serial port, a USB-to-Serial converter can be used to emulate the serial hardware port on a USB port. These are available from different suppliers, you may wish to contact J.W.Lemmens N.V. for support.

It is important that GSData and the Grindo*Sonic* instrument have the same communications settings. The factory settings for the Grindo*Sonic* are: 9600kBaud, 8 Data bits, 1 stop bit, no parity. The settings can be adjusted on the Grindo*Sonic* instrument – see chapter 4.3.9 page 16. The settings can also be checked in the GSData options menu.

7.2. Installation of GSData

No installation is required, simply start the file gsdata.exe from its location.

7.3. Required Windows Settings for GSData

The serial port settings of the Windows PC must be the same as the ones for the Grindo*Sonic* instrument.

2 settings are important:

a.) The PC com port number can only be between 1 and 4. A USB-to-Serial converter will automatically select a com port number. If that number is higher than 4 it needs to be adjusted in the Windows Device Manager.

b.) GSData works with the <.> (point) as the decimal separator. In countries like Germany normally the <,> (comma) is selected. If this is the case please change to the <.> (point): Go to <Start>, <Control Panel>, <Regional Settings> and change accordingly.

7.4. Start of GSData

Before starting the program connect the PC and Grindo*Sonic* using the RS232 connection.

The program starts as follows and is automatically ready to accept measurements from Grindo*Sonic* – provided the correct settings have been made.

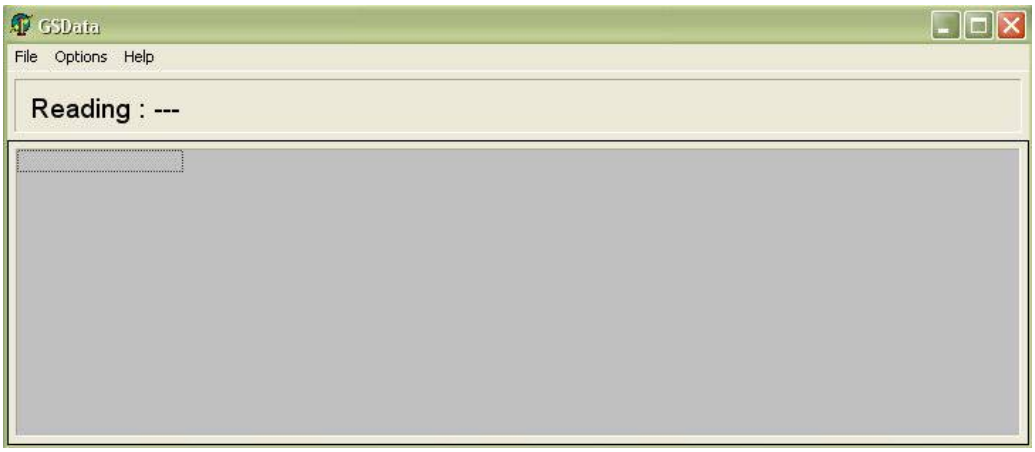


Illustration 39: GSData Main Screen

The RS232 settings for the com port can be selected in the menu <Options>.

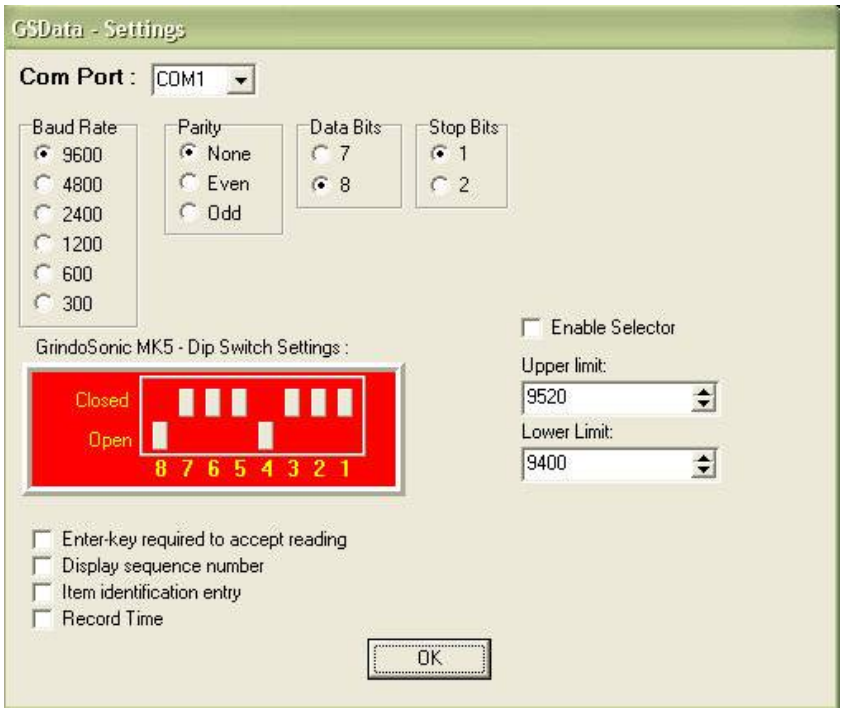


Illustration 40: GSData - Settings

ComPort: After start of GSData com port 1 is checked automatically for availability. If this port is not active an error message indicates this and a different com port can be selected in the <Options> menu (possible are com 1 to com 4. Please check in the Windows Device Manager – especially in the case of a USB-to-Serial converter that the emulated port selected by the converter is within this range (1 - 4).

Dip switch settings can be visually checked with the illustration in the <Options> window. The factory settings of the Grindo*Sonic* are shown in illustration 40 page 52 (please note that switch 6 can be either closed or open). Note: The Grindo*Sonic* must be switched off when modifying DIP switch settings.

Upon closing the window <Options> GSData immediately accepts the transmitted data from Grindo*Sonic.*

7.5. Optional settings in GSData

In the basic factory settings GSData will accept any value and displays these in the value area. Note: Once a value is in the list it can not be deleted in the program GSData.

The following settings in the menu <Options> can be made:

a.) To confirm acceptance of value after a controlled and intended measurement. E.g.: after a piezoelectric detector has been brought in to contact with the test object – which usually also generates a detection of a vibration. Enable tick box:

<Enter-key required to accept reading>

b.) To display of sequential number of measurement, enable tick box:

<Display sequence number>

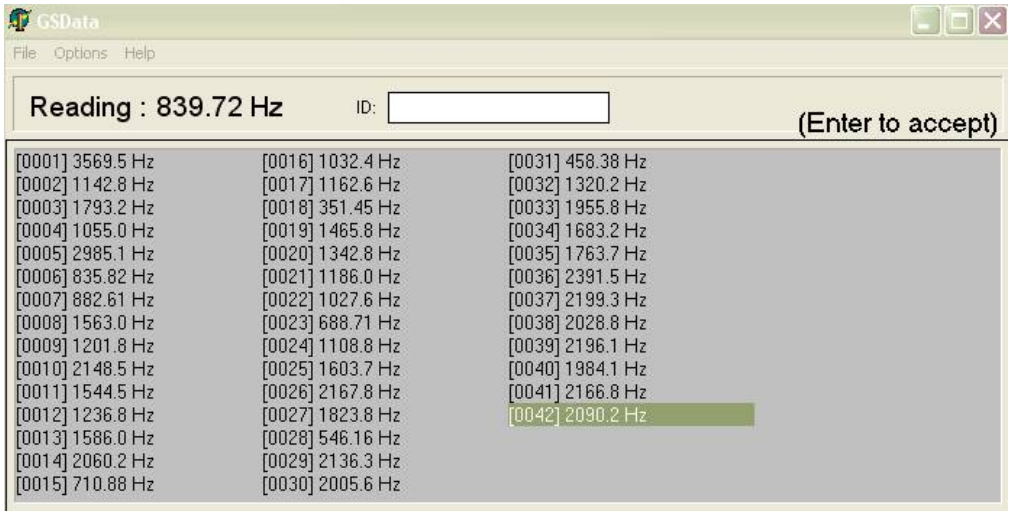


Illustration 41: Options GSData

c.) To manually input a sample identification for each measurement, enable tick box:

<Item identification entry>

d.) Optical selection: A lower and upper limit can be defined. A Grindo*Sonic* value in between these two limits is indicated by a green display. A red display indicates the value outside this defined range.

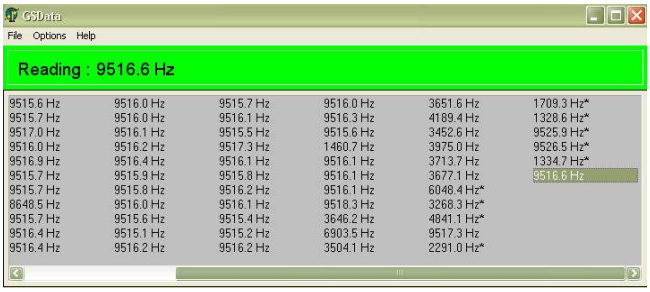


Illustration 42: GSData – within limits

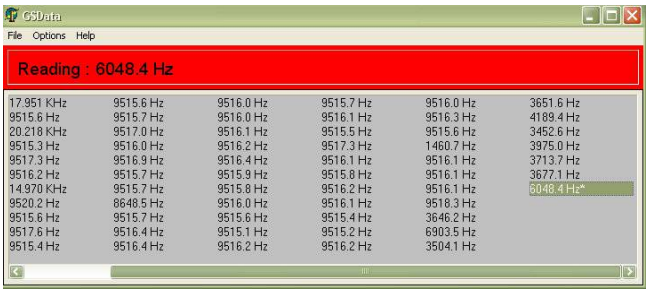


Illustration 43: GSData – outside limits

The range is defined using the menu <Options> and the two fields <Upper> and <lower> limit. Select the tick box <enable selector>.

7.6. Saving and Printing

To save a file in a .txt format use the menu <File> and >Save>. The txt file can then be imported in to an office program for analysis.

<File> + <Print> will print the file to an installed printer.

8. Contact

For service and troubleshooting please contact:

J.W.Lemmens N.V.
Geldenaaksebaan 456
3001 – Leuven
Belgium

email support@grindosonic.com
web www.grindosonic.com