TG-570E

User Manual

Version 1.0, 06/04/24

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Contents

Warning!

Please read this operating manual carefully before operating the TG-570E Electromagnetic-Acoustic (EMA) Thickness Gauge.

The operating manual (hereinafter referred to as OM) includes the information required to inform the operator about the performance and operating procedure of the device – TG-570E Electromagnetic-Acoustic (EMA) Thickness Gauge (hereinafter referred to as the device or thickness gauge). The document contains the specification, description of the design and operating principle, as well as the information necessary for the right product operation. Before using the device, the operator shall read this manual, as the device must be operated by a person aware of its operating principle and design.

The right and efficient operation of the device requires the following:

- measurement procedure;
- conditions of measurement that meet the measurement procedure;
- the trained operator who read this operating manual.

The manufacturer reserves the right to make minor changes that do not impair the technical characteristics of the product. These changes may not be reflected in the text of this document.

The delivery set of the device includes the operation documents that are a part of this manual and the device registration certificate.

This OM applies to all product modifications.

1.0 Description and Operation of the Device and its Components

1.1 Intended Use

The TG-570E Electromagnetic-Acoustic (EMA) Thickness Gauge is designed for measuring the wall thickness of metal and alloy parts, walls of steel pipes, flat-rolled stock, rods, etc., without the use of couplant and preliminary surface preparation. The EMA thickness gauge allows testing through a gap that might be air, rust, paint coating, fluid, plastic, salt deposits, etc.

The thickness gauge can be used in engineering, aerospace, metallurgy, in the mounting of metal structures, thermal power plants and nuclear power plants, field laboratories, and in the testing of vehicles.

1.2 Device Specifications

The TG-570E Electromagnetic-Acoustic (EMA) Thickness Gauge is a portable device enclosed in a shockproof casing with the chipboard, electronic components, and lithium-ion battery.

The main specifications of the device are presented in the table. 1.1.

Table 1.1 – Main Specifications of the Device

Measurement range (depending on a transducer), mm	0.6 - 200
Permissible error, mm	± (0.01h + 0.05) where: h – nominal thickness, mm
Ultrasound velocity range, m/s	100 - 9999
Resolution, mm	0.01
Measurement modes	Autocorrelation (ACF) RISING ECHO 1 PEAK 2 ECHO 2 (dual echo)
Dimensions of the processing unit, max, mm	165×90×50
Power type	a built-in lithium-ion battery
Worktime without charging, min, h	8
Weight of the processing unit, max, kg	0.5
Display size	3.5 inches
Operating temperature range of the processing unit, °C	from -20 to +50
Air humidity, max	98 %, at 35 °C

1.3 Package Contents

- TG-570E Electromagnetic-Acoustic (EMA) Thickness Gauge ..... 1 pc.
- EMAT Transducer ..... 1 pc.
- 2Lemo-2Lemo Cable..... 1 pc.
- Reference Sample ..... 1 pc.
- USB Cable ..... 1 pc.
- Charger ..... 1 pc.
- Scanning Trolley .....As Per Order
- Transportation case ..... 1 pc.
- Operation manual ..... 1 pc.

* By customer request, additional equipment or parts can be included in the package.

1.4 Device Components

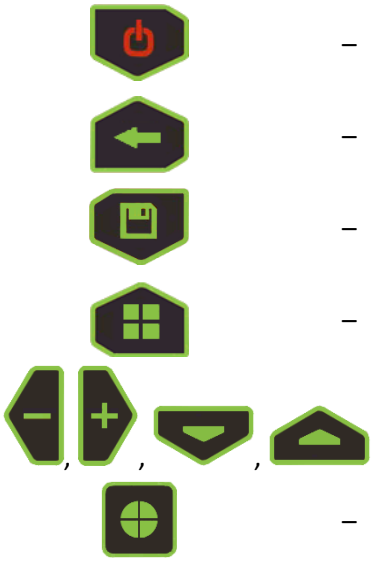
The device consists of a processing unit enclosed in a durable and lightweight aluminum case, and a transducer connected via Lemo-00 type connectors. The thickness gauge is controlled from the keyboard. Signals and readings, the status of the device and other information are presented on a contrast color LCD / TFT display.

The transducers are connected via coaxial cables, through the connectors that are located on the top panel of the housing. The device is powered by a lithium-ion battery. The mini-USB connector, located on the bottom of the case, is used to connect the device to a PC and to charge the battery. Fig. 1.1 shows the components of the device.

1 – Case; 2 – Contrast Color LCD/TFT Display; 3 – Keyboard; 4 – Transducer Lemo-00 Ports; 5 –Mini-USB Slot.

Figure 1.1 – TG-570E Electromagnetic-Acoustic (EMA) Thickness Gauge

The keyboard buttons and their functions:



– Turning on/off;

– "Back" button (returning to a previous section of the menu);

– Saving of a reading;

– Parameters menu;

– Navigation through the menu;

– Confirmation button.

1.5 Transducer

The thickness gauge is designed to function with EMA transducer (fig. 1.2).

1 – EMA transducer; 2 – 2Lemo-2Lemo cable.

Figure 1.2 – EMA transducer

The transducer of the EMA thickness gauge includes the permanent magnet that meets specific requirements to the device operation:

1. If the device is moved near a sharp metal object, the operator should exercise care as it might get magnetized to the transducer and harm operator.

Note – <u>If the device is placed in proximity to a plastic magnet card, this might lead to card failure.</u>

2. If the transducer is placed on a loose and relatively lightweight sample, the operator should ensure the sample will not move unexpectedly.
3. If the operator puts the device on a test object quickly and carelessly, it might couple violently due to additional acceleration caused by the magnetic field. To save the service life of the transducer, it is recommended to place it on a test object smoothly and hold the device carefully.
4. It is recommended to put the device on the test object at a 60-degree angle (fig. 1.3 a). Once the transducer touches the test object, the transducer should be put upright (fig. 1.3 b).

a)

b)

Figure 1.2 – Installation of EMA transducer

1.6 Structure and Functioning

The operating principle of the device is based on measuring the propagation time of an acoustic wave through the test object. The measured time is converted into thickness using the preset velocity of the ultrasonic wave propagation.

The acoustic wave is formed through electromagnetic-acoustic conversion directly on the surface of the test object, bypassing the contact medium between the transducer and the test object. Due to this conversion, the wave is not distorted in this medium.

The special data processing algorithm allows measuring the thickness of the test object correctly in the presence of interfering factors such as metal anisotropy, multiple reflectors, and external noise. The device eliminates the human factor, making thickness measurements fully automatic.

1.7 Operating Modes

The device works in the following modes:

1. "MEASUREMENT":
   - "AUTO";
   - "MANUAL";
   - "B SCAN";
   - "CONTROL".
2. "ARCHIVE":
   - "VIEW" – viewing of the saved readings;
   - "DELETE" – removal of the selected measurements from the archive;
   - "DELETE ALL" – removal of all the saved measurements from the archive;
   - "EXIT".
3. "SETTINGS":
   - "LANGUAGE";
   - "BRIGHTNESS";
   - "PALETTE";
   - "SOUND";
   - "PROBE";
   - "SCALE";
   - "ALL RESET";
   - "TIME";
   - "DATE".
4. "INFORMATION":
   - about the device.

1.8 Means of Measurement, Device, and Accessories

The operability of the device is estimated using reference samples. The measurement error of the device must be within the permissible error.

Adjustment and setting of the device must be done by NDT Systems.

1.9 Marking and Sealing

NDT Systems Logo and instrument identifiers are printed on the front panel.

The serial number is located on the back of the device.

1.10 Packaging

The electronic unit and the probe are delivered in a packing container, which prohibits damage during transportation.

To avoid mechanical damage to the cable and connectors of the device, disconnect the probe from the device before packing.

2 Intended Use

2.1 Operational restrictions

The device must be operated away from dust and aggressive environments, and with consideration of features of the test objects in line with the agreed technical specifications, and the device must be used within its technical characteristics.

The magnetic radio interference at the place of operation of the thickness gauge must not exceed the value that could impair the operation, i.e. it must not create the voltage at the amplifier input of the thickness gauge that is more than half of its maximum sensitivity.

If the magnetic field of radio noise is strong, the place of operation of the thickness gauge must be shielded from the external magnetic field.

The device must be used by a person who has read this operating manual.

If the device is carried to the place of operation at sub-zero temperatures and placed in a room with a temperature above zero, it should be kept in a package for at least 6 hours to avoid the moisture buildup.

2.2 Preparations for use

2.2.1 Visual inspection

Visually inspect the device and make sure there is no damage to the electronic unit, probe, connectors, and connecting cable before operation.

2.2.2 Battery Charging

To charge the battery, connect the power unit to the Micro USB connector on the bottom side of the device. The device can be operated during the charging.

The full battery charging takes up to 14 hours. When the device is being charged, it is prohibited to leave it unwatched. The device can be also charged by connecting it to a PC.

To avoid battery failure during long storage, the battery should be charged every 2 months, even when the device is not in operation.

2.2.3 Transducer Connection

Using the connecting cable, connect the probe to the connectors on the top panel of the instrument. The transmitting connector must be connected to the left socket (marked with a red label); the receiving connector must be connected to the right socket (Fig. 2.1).

Note – Connecting and disconnecting the probe to the instrument is allowed only when the power supply of the thickness gauge is turned off.

Warning!

To prevent damage to connectors and cables, follow the instructions for handling these connectors below!

The connectors featured in the device (Fig. 2.1) consist of two parts: the device socket and the pin (plug) of the cable.

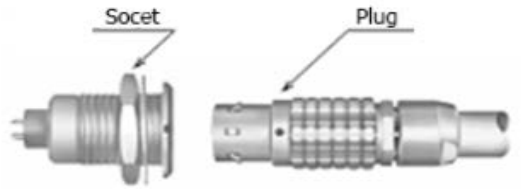


Figure 2.1 – Connectors of the device

The way of connecting and disconnecting the plug and socket is shown on Fig. 2.2.

Warning!

When disconnecting the plug from the socket, grasp its body in the grooved area; do not pull on the cable!

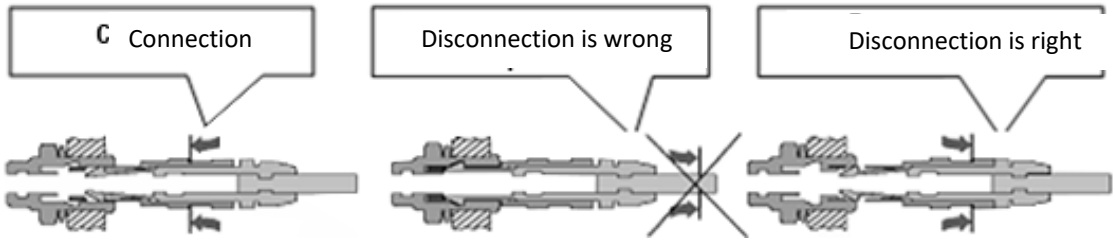


Figure 2.2 – Handling of the connectors

The probe is connected to the device as follows: the emitting cable of the split-type probe is connected to the connector marked with a red dot, and the receiving cable is connected to the other connector on the top panel of the thickness gauge by inserting the cable connectors until you hear a click.

2.3 Operating procedure

2.3.1 Turning on

Switch the device on by holding the key “  ” on the control panel, until the short-time screensaver appears on the display (fig. 2.3).

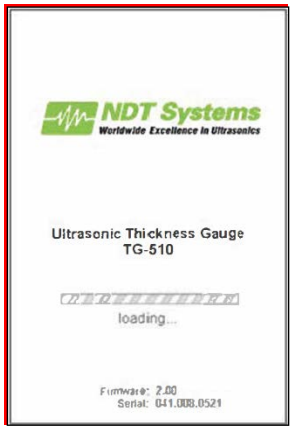


Figure 2.3 – Display after turning the device on

After displaying this logo, the device will go to the main menu (fig. 2.4).

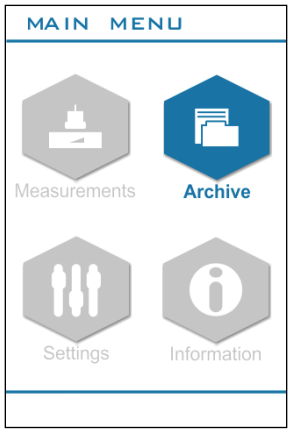


Figure 2.4 – Main menu

The main menu of the thickness gauge consists of four sections:

1. “MEASUREMENT” – entering the measurement mode;
2. “ARCHIVE” – displaying of all the saved measurement results;
3. “SETTINGS” – in this section, the following parameters can be set: language, brightness, palette, sound, clear SD card, probe, material, scale, time and date;
4. “INFORMATION” – displaying the information about manufacturer and the device.

2.3.2 “MEASUREMENT” Mode

To enter the “MEASUREMENT” mode, choose the needed point using “ ” and “ ”, and confirm the selection by pressing “ ”.

In the MEASUREMENT mode, the display is split into two sections: main and informational (top part of the display) (fig. 2.5). The main section contains the working section of the mode, and the informational section features the battery charge, connection to PC, SD card connection, and the current time.

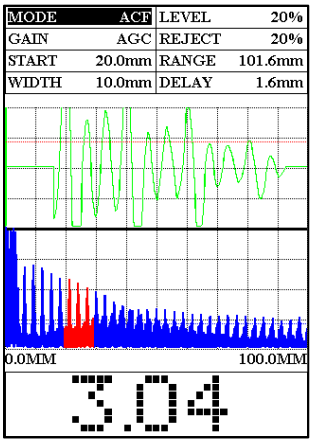


Figure 2.5 – Display of the thickness gauge

In “MEASUREMENT” mode, the thickness gauge can be operated in the following modes:

- “AUTO”;
- “MANUAL” mode;
- “B SCAN” mode;
- “CONTROL” mode.

To switch the operating mode of the thickness gauge, press “ ”, and select the needed mode by using “ ” and “ ”, press “ ” to confirm the selection.

To navigate through the parameters, use “ ” and “ ”, and use “ ” and “ ” to change the value.

The operator can change the resolution of the selected parameter by pressing “ ”. The selected resolution is displayed by a special number (, , ,) next to the value being changed.

2.3.2.1 “AUTO” Mode

In this mode, the device automatically analyses the measured signals, selects the measurement method, sets the parameters of the receive path, and displays the measured thickness value.

In the “AUTO” mode (fig. 2.6), the speed of ultrasound velocity in the test object must be set (the measurement of the velocity). The ultrasound velocity should be set manually in the “Vel.” parameter (from 1000 to 9999 m/s).

Caution!

The device employs a transversal wave. The speed of propagation of transversal waves in steel is 3250 m/s.

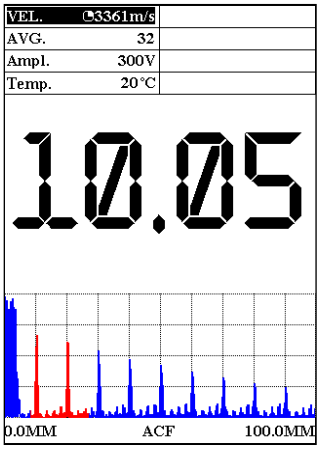


Figure 2.6 – “AUTO” mode

When the temperature of the product changes, the velocity of ultrasound in the material also changes, the higher the temperature, the lower the speed. As the temperature of a steel sample increases by 55 °C, the speed of sound decreases by approximately 1% (the exact value depends on the type of alloy).

The device is equipped with a temperature compensation function for a given material, which, taking into account the change in temperature of the product, automatically adjusts the speed of ultrasound in the material.

For operation under normal conditions, the temperature of the controlled object is set to +20 °C in the “TEMPERATURE” parameter, and the thickness of the product is measured without compensation for the ultrasound velocity.

With a significant change in the temperature of an object, it is recommended to measure its surface temperature using contact or a pyrometric temperature meter. Set the resulting value in the "TEMPERATURE" parameter, after which the measurement of the thickness of the product is carried out taking into account the compensation of the speed of ultrasound.

When testing materials with high attenuation, big objects, and using a large sounding range, the noise amplitude can be compared to the amplitude of the valid signal and the valid signal can be difficult to see with increased noise. For these cases, the device implements averaging that can be done by 2, 4, 8, 16, 32, 64 and 128 signals. The excitation amplitude can be set in the range from 66V to 400 V.

2.3.2.2 "MANUAL" Mode

In the "MANUAL" mode, the measurement and testing are performed, including setting of the device according to a specific task (fig. 2.7). All parameters for the settings of the measurement are divided into categories (tab. 2.1) and depending on the selected category, the operator can set different parameters.

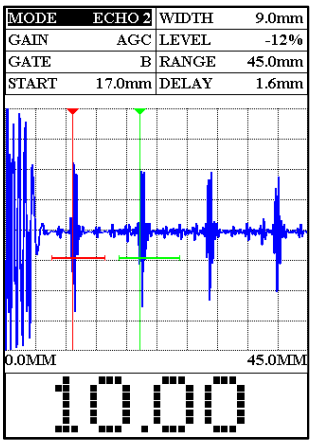


Figure 2.7 – "MANUAL" mode

Table 2.1 – Parameters of "MANUAL" mode

Groups	Parameters						
ACF	GAIN	START	WIDTH	LEVEL	REJECT	RANGE	DELAY
RISING	GAIN	VEL.	START	LEVEL	RANGE	DELAY	AVG.
ECHO 1	GAIN	VEL.	START	WIDTH	LEVEL	RANGE	DELAY
PEAK 2	GAIN	START	WIDTH	LEVEL	RANGE	DELAY	LEVEL
ECHO 2	GAIN	GATE	START	WIDTH	LEVEL	RANGE	DELAY

Description of the parameters of the “MANUAL” mode:
– “GAIN”: amplification is adjusted automatically (AGC), or manually;
– “START”: the point of start of the selected gate (from 0 to the maximum measurement range);
– “WIDTH”: the width of the selected gate of the beam control. This value can vary from 0 to the maximum measurement range. The total of start and width of the gate cannot exceed the maximum measurement range;
– “LEVEL”: the threshold of the amplitude of processing echo signals. The range is from 0 to 100%;
– “REJECT”: duration of scanning;
– “RANGE”: the duration of the reflected sweep;
– “DELAY”: this parameter sets the delay of the start of scanning against the monitoring pulse;
– “VEL.”: display of the set speed of ultrasonic oscillation in the tested material (range from 1000 to 9999 m / s);
– “AVG.”: turn on / turn off, and set the quantity;
– “LEVEL”: turn on / turn off;
– “GATE”: a selection of the gate. It can be A or B.

The “*ACF*” mode – calculation of the autocorrelation function of exponentially reflected signals in the test object. This mode is used for testing thin objects. The reading in this mode is shown in fig. 2.8.

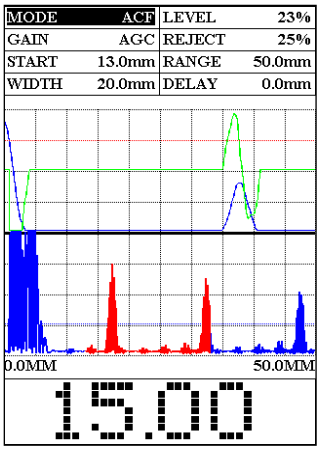


Figure 2.8 – The “ACF” mode

The “RISING” mode – the thickness of the test object is measured by the signal flank within the test area. The reading in this mode is shown in fig. 2.9.

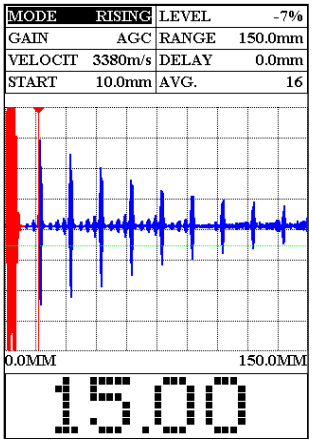


Figure 2.9 – “RISING” mode

The “*ECHO 1*” *mode* – the thickness of the test object is measured by the first reflected echo signal, the reading in this mode is shown in fig. 2.10.

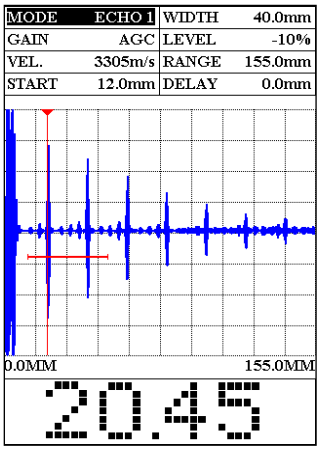


Figure 2.10 – “ECHO” mode

The “PEAK 2” *mode* – the thickness of the test object is measured by two peak signals in the test area (fig. 2.11).

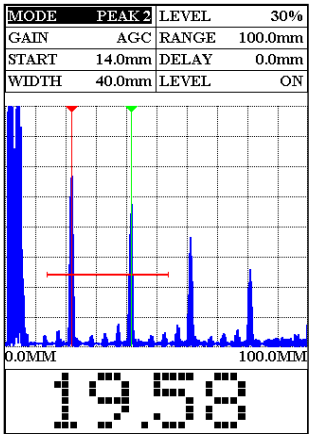


Figure 2.11 – “PEAK2” mode

The “*ECHO 2*” mode – the thickness of the test object is measured by the time between two echoed signals (fig. 2.12). This mode is used for measurement of the thickness of products excluding the thickness of the coating.

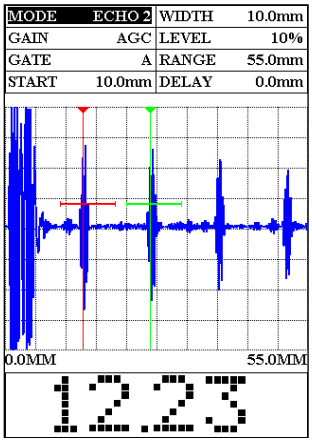


Figure 2.12 – “ECHO 2” mode

2.3.2.3 "B SCAN" Mode

"B SCAN" mode (fig. 2.13) is used for displaying of B-Scan that is the shape of the test object. This mode is used for detection of corrosion damage, wall loss, and lamination when scanning the test object and graphical B-scan.

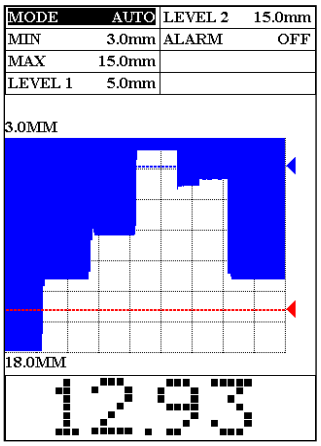


Figure 2.13 – "B SCAN" mode

All the settings of parameters of measurement in the "B SCAN" mode are divided into groups (tab. 2.2).

Table 2.2 – "B SCAN" mode parameters

Groups	Parameters				
AUTO	MIN.	MAX.	LEVEL 1	LEVEL 2	ALARM
ACF	MIN.	MAX.	LEVEL 1	LEVEL 2	ALARM
RISING	MIN.	MAX.	LEVEL 1	LEVEL 2	ALARM
ECHO 1	MIN.	MAX.	LEVEL 1	LEVEL 2	ALARM
PEAK 2	MIN.	MAX.	LEVEL 1	LEVEL 2	ALARM
ECHO 2	MIN.	MAX.	LEVEL 1	LEVEL 2	ALARM

Description of the "B SCAN" settings:
– "MIN.": the lowest value of the measurement range;
– "MAX.": the highest value of the measurement range;
– "LEVEL 1" and "LEVEL 2": minimum and maximum measurement threshold;
– "ALARM": turning on/off of the sound signal.

2.3.2.4 “CONTROL” Mode

This mode is used when it is necessary to examine the products by the exact thickness (minimum and maximum). When the measured thickness exceeds the set thresholds, an alarm is triggered so the product can be rejected.

“CONTROL” mode (fig. 2.9) allows operator to estimate the corrosion damage in the percentage of the reference thickness value.

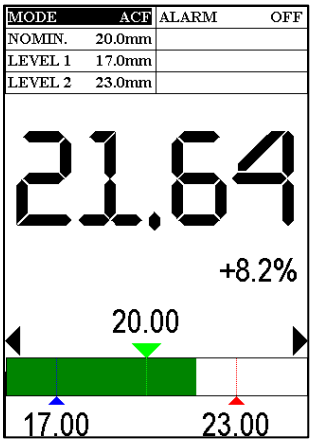


Figure 2.9 – “CONTROL” mode

All parameters of settings of the measurement in the “CONTROL” mode are divided into groups (tab. 2.3).

Table 2.3 – “CONTROL” mode parameters

Groups	Parameters			
AUTO	NOMIN.	LEVEL 1	LEVEL 2	ALARM
ACF	NOMIN.	LEVEL 1	LEVEL 2	ALARM
RISING	NOMIN.	LEVEL 1	LEVEL 2	ALARM
ECHO 1	NOMIN.	LEVEL 1	LEVEL 2	ALARM
PEAK 2	NOMIN.	LEVEL 1	LEVEL 2	ALARM
ECHO 2	NOMIN.	LEVEL 1	LEVEL 2	ALARM

Description of settings of the “CONTROL” mode:
– “NOMIN.”: reference (nominal) thickness of the sample;
– “LEVEL 1” and “LEVEL 2”: minimum and maximum thresholds of the thickness measurement;
– “ALARM”: Turning on/off of the sound signal.

2.3.3 “SETTINGS” mode

When “SETTINGS” mode is selected (fig. 2.14), the device will go to the settings of the next parameters:

- “LANGUAGE”: setting the language of the device menu (English and Spanish are available);
- “BRIGHTNESS”: change of the display brightness (10%, 20% … 100%);
- “PALETTE”: selection of the color scheme (01, 02);
- “SOUND”: Turning on/off (“ON”, “OFF”);
- “PROBE”: the selection of the stored transducers;
- “SCALE”: measurement units (mm, inch, us);
- “ALL RESET”: reset to factory settings, delete all saved data;
- “TIME”: time setting (24h);
- “DATE”: setting the date, month, and year DATE/MONTH/YEAR.

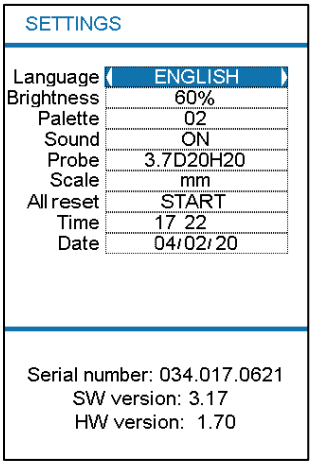


Figure 2.14 – “SETTINGS” mode

To navigate through «SETTINGS» menu, use “ ” and “ ” buttons, to select the parameter to be changed, press “ ”, and select the needed value by pressing “ ”, “ ”, that is confirmed by pressing “ ”.

2.3.4 “ARCHIVE” Mode

This mode allows seeing all the saved measurement values and, if needed, download the selected file to continue working with the required settings (fig. 2.15).

Figure 2.15 – “ARCHIVE” mode

The saved measurement values are listed and sorted by the date of creation. To handle the saved files, select the saved file by using “ ” and “ ”, and press “ ”.

2.3.5 “INFORMATION” Mode

In this mode, the operator can view the product information: battery charge, voltage, consumed voltage, total operation time, measurement time, serial number, firmware version, and chipboard version (fig. 2.16).

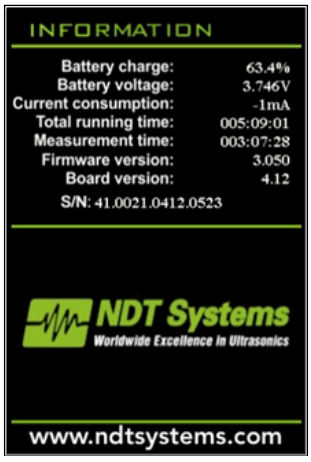


Figure 2.16 – “INFORMATION” mode

2.3.6 Measurement

Before using the device, make sure that the battery is charged sufficiently. The green battery icon confirms that the battery is charged to 100%. If there is no charge or the charge is low (the red icon), the battery must be charged by a charger or by connecting the device to a PC.

1. Connect the EMA transducer to the device.
2. Turn the device on by pressing “ ”.
3. Select the operating mode of the thickness gauge by pressing “ ” and set the needed parameters.
4. Put EMA transducer on the teste object and achieve a stable value on the display (fig. 2.17).

Figure 2.17 – Measurement

5. To save the measurement value, press “ ”. Then, the name of measurement can be set with a virtual keyboard (fig. 2.18).

Figure 2.18 – The input of the measurement

Use “  ”, “  ”, “  ” and “  ” to navigate through the keyboard, select the needed symbol by pressing “  ”.

6. To turn the device off, enter the main menu and press “  ”.

3 Maintenance of the device and its components

3.1 Safety precautions

After use of the device, it is recommended to inspect it periodically to check the following:

- operability;
- compliance with the operating requirements;
- battery charge level;
- absence of damage to the device components.

When using the charger connected to 110V at 50 Hz, the operator should observe the regulations in “Safety procedure when operating consumer electronic units”.

If the device is not in operation for an extended period, the batteries must be disconnected from the power supply. Using this, the storage regulations of the battery must be observed.

The device can be used only by persons instructed and qualified to operate ultrasonic measuring devices.

3.2 Verification

Recommended calibration interval at least once a year.

The verification (calibration) procedure - further verification, applies to the TG-570E Electromagnetic-Acoustic (EMA) Thickness Gauge and establishes methods and means of their primary and periodic verification.

Note – Verification of the device and the making of a verification certificate shall be done only under the buyer's order.

4 Warranty

1. WARRANTY:

NDT Systems warrants that reasonable care was used in the choice of materials and the manufacture of this instrument, and that the instrument conforms to the published ratings and characteristics applicable to the instrument at the time the instrument is shipped to the Buyer. This warranty shall extend for a period of one year from the date of shipment of the instrument (FOB) Seller's plant and shall in no event extend beyond such term. The Buyer shall notify NDT Systems by registered or certified mail, return receipt requested, of any claim of discovery of such defect. Failure to notify NDT Systems within the time and in the manner specified herein shall constitute a waiver of any such claim of defect or breach of warranty. The final determination of the existence of a defect or breach of this

warranty shall be made by NDT Systems. This warranty shall extend to the Buyer only and shall not be assignable or transferable to any other person.

2. DISCLAIMER OF WARRANTIES:

THERE ARE NO WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANT ABILITY OR FITNESS FOR A PARTICULAR PURPOSE, OTHER THAN THOSE WARRANTIES SET FORTH IN THE PARAGRAPH ENTITLED "WARRANTY" ABOVE.

The above warranty shall not apply to digital panel meters and items with a limited life, such as batteries, probes or cables, nor to any instruments which have been subjected to misuse, improper installation or repair, alteration, or use beyond the published maximum ratings of the instrument.

3. BUYER'S REMEDIES:

The Buyer's sole and exclusive remedy for breach of the above warranty shall be the repair or replacement of the instrument by NDT Systems free of charge. The Buyer shall return the instrument to NDT Systems, transportation prepaid. NDT Systems shall promptly repair or replace the instrument and return same to Buyer, FOB Seller's Plant, collect.

If, for any reason, NDT Systems is unwilling to repair or the instrument or, because of circumstances, the exclusive remedy provided herein fails of its essential purpose, or operates to deprive either party of the substantial value of its bargain, then the Purchaser's exclusive remedy will be the return of the purchase price for the instrument. The liability of NDT Systems shall in no event be greater than the full amount of the purchase price for the instrument.

Any attempt by NDT Systems to repair or replace any instrument sold hereunder shall not constitute an admission that the instrument, or any part thereof, is defective within the meaning of the above warranty, nor that NDT Systems has any legal responsibility to make such repair or effect such replacement.

Any such attempts, if unsuccessful, shall not create any liability on the part of NDT Systems and the purchaser is limited to the remedy set forth herein.

4. LIMITATIONS ON LIABILITY:

NDT Systems, Inc. Standard Terms & Conditions can be found at:

https://www.ndtsystems.com/standard-terms-conditions

5 Storage

The storage conditions of the device shouldn't exceed ambient temperature from +5 °C to +40 °C and relative humidity up to 80 % at the temperature of 25 °C. The temperature recommended for long-time storage is 10 °C – 30 °C.

During short-term storage and in the periods between applications, the device shall be stored in the intended packaging container. The place of storage should be free from vapors of aggressive media (acids, alkali) and direct sunlight. The device shall not be exposed to rapid shocks, falls or strong vibrations.

The devices shall be placed on storage racks or palletized in the transportation container.
For long-term storage, the device must be preserved; the processing unit, transducer, and power unit should be placed into separate plastic bags and put in separate sections of the transportation case of the device.

6 Transportation

The packed devices can be transported by any kind of carrier upon fulfilment of the following requirements:

- Transportation is performed in the factory container;
- No direct moisture influence;
- The temperature does not go outside the range from -50 °C to +50 °C;
- Humidity does not exceed 95 % at the temperature up to 35 °C;
- Vibration is in the range 10 to 500 Hz and the amplitude up to 0.35 mm and acceleration up to 49 m/s^2;
- Shocks of peak acceleration of up to 98 m/s^2;
- The devices in the vehicle are fastened to avoid falling and mutual bumps.

To avoid the moisture buildup inside the device after transportation from the sub-zero environment to a warm place, the device should be held in a container for 6 hours at room temperature.

7 Disposal

Device disposal can be done according to common waste disposal practices. Disposal shall be done by the type of components: plastic, metal, and fastening components.

APPENDIX I

The velocity of transversal wave propagation in materials

Table 1 – Velocity of transversal wave propagation in the materials

Material	The velocity of transversal waves, m/s
Aluminum	3100
Beryllium	8900
Bronze (phosphorous)	2330
Tungsten	2870
Iron	3200
Gold	1200
Cadmium	1500
Yellow metal	2120
Magnesium	3060
Manganese	3270
Copper	2260
Molybdenum	3350
Nickel	2960
Tin	1670
Lead	700
Silver	1650
Steel	3250
Titanium	3100
Chrome	3975
Zinc	2440
Cast iron	2600

NOTES

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