КОНТЕСТ

BT-77 Bearing Tester with Non-Contact Tacho

Operating Instruction Manual

CONTENT

INTRODUCTION

This manual is intended for the study of the BT-77 bearing condition tester. The manual contains description of the BT-77 bearing checker operating principle, operating procedures of the intended use and bearing shock pulse evaluation concept.

1.0 BT-77 INSTRUMENT DISCRIPTION AND FUNCTION

1.1 Specification

1.1.1 Standard Conditions for Operation:

- Operating temperature (device & sensor), -10 to 55°C, (±5)°C;
- Relative humidity 80% at temperature 30 °C;
- Atmospheric pressure, 84 to 106.7 KPa (630 - 800 mm Hg);
- Resonance frequency, 32 kHz;
- Measurement unit, dB_i, dB_c, dB_m;
- Range, max. 99dB;
- Resolution, 1 dB;
- Accuracy, ± 5%;
- Operating temperature (tacho), 10 to 55°C, (±5)°C;
- Tachometer range, 50-30,000rpm;
- Tachometer resolution, 1rpm;
- Tachometer sensing distance, up to 1m;
- Memory capacity, 2MB;
- PC communication port, USB;

1.1.2 System Specification

- Power supply, 3.6V NiMH rechargeable battery.
- Continuous operation on batteries, not less than 10 hours.

- Current consumption 220V, 50 Hz AC, not more than 5VA.
- The limits of complementary error of the instrument at voltage changing from 3.6Volts to 2.8Volts.
- Probability of no-failure operation, not less than 0.92 per 2000 hrs.
- The average instrument life, not less than 10 years.
- Failure time, 1000 hours. The average failure time is set for stan-dard conditions for operation.
- Dimensions, not more than 60 x 110 x 30 (mm).
- Weight, not more than 210 gram.

1.2 Overview on Rolling Bearing Condition Monitoring

Ideally, rolling bearing elements are separated by a protective lubricant film, which impedes their collision. However, manufacturing defects, damages, which appear during operation, dirt in the bearing, insufficient or incorrect lubrication – all these factors cause the collision of the bearing elements and, as a result, acoustic oscillations of a wide spectrum are generated in the bearing body.

A specially designed transducer (patent №18652) is used to filter out the part of this spectrum that carries information on the bearing faults detection. The transducer filters those acoustic oscillations which are generated by the bearing defects, and converts them into electronic signal proportional to the magnitude of shock pulse signal, that is amplified and measured by the BT-77 electronic unit in the relative units of decibels (dB).

A real new bearing is just from the beginning of its use, a source of induced vibration, the amplitude of the shock pulse of which is dB_i.

The dB_i, initial value depends on the large number of factors; however, in practice it is possible to limit them to diameter D (mm) of the neck and its rotating speed N (rpm). The

value of dB_i features the condition of a new correctly installed and lubricated bearing.

The shock pulse amplitude increases as a result of wear and improper use. Shock acceleration amplitude over running the value of dB_i - dB_{sv} features a damage, and is used for the evaluation of bearing condition.

This enable BT-77 to tell the difference of shock pulse values induce is low shock and high shock, a normalized measurement scale call dB_n is uses, see beneath Table-1.0.

dB_n	=	0 - 25	Good condition
dB_n	=	25 - 40	Satisfactory condition
dB_n	>	40	Poor condition, breakdown risk

Table-1.0

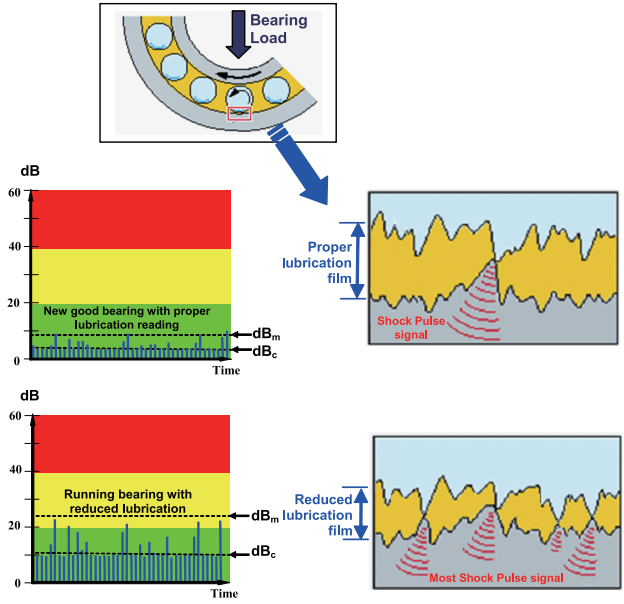


Fig-1.0

50	-
	- **dB_a** - absolute value at measuring point
40	-
	- **dB_{sv}** - value features bearing failure (dBa - dBi)
30	-
20	-
	- **dB_i** - original value of the shock acceleration amplitude
10	-
	-
0	- response threshold of the bearing checker
-5	-
-10	-

Figure-1.1 - An example of these values ratio.

Pattern of the induced oscillations, which are registered by BT-77, changes according to the bearing faults.

1.3 Understanding Shock Induced "Carpet value" and "Maximum value"

At the measurements, the bearing checker allows to filter out and measure two specified values of the shock acceleration amplitude: the Carpet value (dB_c) and the Max. value (dB_m).

The dB_c background value (the Carpet value) refers to the frequent collisions of the bearing surface roughness, dB_c it gives important information regard to the lubrication of the bearings, how well the bearing have been mounted and the way in which they are been loaded, and is indicated by the continuous light of LED. The dB_m Max Value refers to the separate shocks, characterizing the faults level, and is indicated by separate LED flashes.

For instance, at the shock acceleration amplitude measuring of a well lubricated and correctly installed bearing, the dB_m is only slightly higher than dB_c. But when one measures shock acceleration amplitude of a bearing having faults, these faults are detected by dB_m maximum values, at that, the background dB_c value depends on the lubrication condition, and can grow increase substantially when there is insufficient lubrication followed by frequent metal-to-metal contacts.

Increase of dB_c background value may be caused by other reasons as well, e.g. at the drive coupling misalignment. It is easy to distinguish between these cases – with the coupling misalignment there will be the same picture for the bearings on the both sides of the coupling.

Results of the shock acceleration amplitude measurement for drives bearings can be influenced by shocks produced during the running in of a gear mesh, which can be transferred onto the bearings. However, mostly the gear teeth hum is so low that does not impede the measurement.

With the shocks, originated by the gear wheels defects, the dB_m Max Value increases sharply for the two bearings simultaneously (on both sides of gear).

The greatest effect from the technical state monitoring of bearings is reached when measuring results are being put on graph against the time factor. At this, a forecast of the technical state becomes possible. Example of the measurements results processing is given in Table-1.0 .

1.4 Tachometer

The TI-7 tachometer operation is based on the measurement of frequency of infrared ray return from the reflective tape (or another marker) fixed on the turning shaft. A white marker pen is provides in the package so that user can mark the rotor to get good

contrast when taking RPM measurement.

The measured RPM reading can also be saved within the device with file name end by "tac" extension.

1.5 Design of BT77

Constructively BT-77 Bearing Tester is designed in a light and strong alloy casing protected by silicon sleeve with the rechargeable internal battery power supply, socket for the measuring probe and USB port for tachometer sensors or file upload to PC for data management. The controls and connectors location is shown on the Fig. 1.2a & Fig. 1.2b.

Fig. 1.2a

Fig-1.2b Top view of BT-77

1. BT-77 device
2. Bearing shock pulse measuring probe
3. Tachometer sensor and magnetic stand
4. Socket for measuring probe
5. USB port for Tachometer sensor/ PC com
6. Socket for AC charger
7. Soft membrane push pad for operation
8. Back-lite monochrome LCD display

1.5.1 Operation Keys

Turn ON	Enter setup menu
OK / Start	Return / back to earlier step
Adjust up or increase	Adjust down or decrease/ OFF (press and hold)

2.0 TAKING MEAUSREMENT WITH THE INSTRUEMNT

Before using the instrument, it is a good practices to check proper mechanical functioning of the controls, connectors and power state when switch on.

Note the device automatically switches off after 150 seconds when no further operation.

2.1 Instrument Display and Measuring Modes

To switch “ON” the BT-77 bearing tester, press . The device perform self test as shown in Fig-2.1 and automatically enter the first default operation mode - USB interface, Fig-2.2.

To connect device to PC for report print and view, make sure device is set in USB interface mode and press to ready for interface. Connect the USB cable between device and PC via the USB port.

To go to other mode, press either or to scroll through the four operating mode option.

Fig-2.1

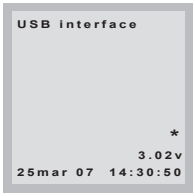


Fig-2.2

2.1.1 Setting the system real time and date

- At any operation mode display, press  to enter date/ time menu follow by  to see set items.
- Press  and  to set the minutes and follow  to confirm correct input setting. The screen proceeds and show subsequence setting for hours, day, date, month and year to be set in same way.
- When all date and time settings are correctly input, press  twice to return operation mode display to begin new task.

2.2 Taking Bearing Diagnosis Measurements

2.2.1 Selection and setting up the measuring points

While selecting the measuring points, take into account the following and see Fig3-3:

- ✓ Metal column between the probe tip and bearing must be, if possible, straight (don't take readings from the cap that covers the bearing housing).
- ✓ It is critical that the measuring point to be selected as close as possible to the bearing.
- ✓ While monitoring the bearing, use the same measuring point.

Setting up measuring point:

- ✓ Measuring points should be free of paint and dirt;
- ✓ Mount the stationary extenders (pins or bolts 6-8 mm) of desired length or provide holes for measuring probe access in the bearing housings located behind the machine protective gears or caps.

ATTENTION! *Keep the probe location and the force the same during the measuring cycle!*

The BT-77 Tester automatically switches off after 150 seconds when no further operation.

2.2.2 Set up initial parameter & take bearing measurements

- Press ⏻ to turn on BT-77, press ⇩ key to switch display to bearing diagnosis measurement mode shows in Fig-2.3.
- Press 👍 to begin new measurement shown in Fig-2.4 and press 👍 again to start taking reading.

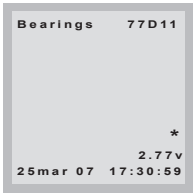


Fig-2.3

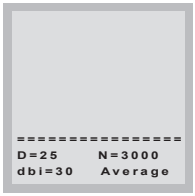


Fig-2.4

- If parameters on screen are NOT correct set and need to be change, press ▶≡ twice to display change of dB_i setting (*see note below for dB_i setting*).
- If dB_i is unknown, press ▶≡ again to change D (diameter of shaft or bearing I/D dia) by using ⇧ or ⇩ key to set and press ▶≡ to confirm the D input value and go to next setting parameters.
- Screen will display RPM (shaft rotating speed) setting, same using ⇧ or ⇩ key to set and press ▶≡ to confirm.
- The display now shows “Single” “Average” or “Contin”, setting. To change the calculation method by using ⇧ or ⇩ key to set.
- Now press ▶≡ twice to view the newly calculated dB_i value with changed input parameters.
- If all parameter have set correctly, press ⏎ to return ready for measurement screen, Fig-2.4.
- To begin new measurement, press 👍 to start taking reading. Wait for measured to display with evaluation as shown in Fig-2.5b

Note: *dB_i can be input manually or calculate by device after input of the bearing inner*

diameter or shaft diameter "D" and RPM, "N" speed for the machine.

ATTENTION!

Measurement calculation method:

Single - *single reading with dB_i taken into account. Result – normalized value of dB_m, dB_c for condition evaluation based on the technology developed by the Central Research & Design Institute of Navy.*

Cont. - *continuous reading with dB_i taken into account. Result updates every seconds. Press "STOP" button to end the procedure.*

Average - *five readings are taken with dB_i taken into account; the result is their arithmetic mean value.*

2.2.3 Taking bearing diagnosis measurement and save

After identified the measuring point on machine, place the probe firmly against the machine at the desired measurement location and ready to take reading.

- Press  and wait until bearing reading is displayed. While taking the reading, display show "busy..." message, Fig. 2.5a, and the measuring cycle is approximately 30-40 second if "Average" method is selected.
- Once measurement finish, the display shows Fig-5b, the measuring results: the Max value, Carpet value (**dB_m and dB_c**) and condition of the bearing evaluated on dB_n chart as final result.

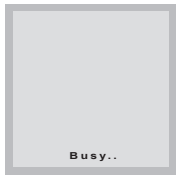


Fig-2.5a

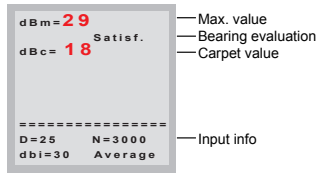


Fig-2.5b

- To save the reading, Press  follow  OK key to enter main directory.
- Press  again to make new directory, save, read or delete folder or press

or to select desired directory (directory line are shows with) *series of numeric without "xxx.b77"or "xxx.tac" extension*) to be saved, see Fig-2.6 in section 2.2.4 save measured file.

- Press to confirm data saved.

2.2.4 File format and open measured file

For BT-77, any measured reading on display reading is saved within the device in standard format with self device generated directory or file names in term of date and time ("0325" mean 25 March and "165301" mean 16hrs, 53 mins, 01 sec) follow by "b77" extension format for data file, see Fig-2.6.

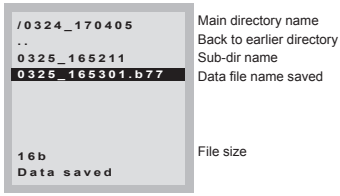


Fig-2.6

- To open data file for review, press or to go to my documents screen and press to see file and directory as Fig-2.6.
- Press or to move cursor to data file (with b77 extension) and press to open for view.

2.3 Evaluation of the Measuring Results

Bearing condition is defined by the shock acceleration magnitude dB_n.

0...25 dB_n	- good condition, optimal operating conditions;
25...40 dB_n	- satisfactory condition, the measurements are taken in short time interval to evaluate the type of coming;
>40 dB_n	- poor condition, visible failures appear, operating conditions be came worse, accident may happen.

The measuring results are recorded into the report. While continuously monitoring the equipment condition, it is recommended to use the records as graphical data representation to show clearly the tendency of condition change at the measuring points.

Table-2

Pump inventory numbe1121r																
Date	Bearing № 1			Bearing № 2			Bearing № 3			Bearing № 4						
	10	30	50	10	30	50	10	30	50	10	30	50				
18.01.90																
31.02.90																
15.02.90																
22.02.90																
01.03.90																
15.03.90																
22.03.90																
28.03.90																

Diagrams in the Table-2 show as follows:

1. Bearing №1 is in good technical condition
2. After the measurement dated 15.02.90 the lubrication was replaced inthe bearing №2, presently this bearing is in good condition and needs close monitoring (more frequent measurements).
3. Bearing №3 is in good technical condition.
4. Condition of bearing №4 is getting worse, after the measurement dated 15.03.90 the lubrication was replaced, no positive results were shown, it is advisable to replace the bearing to avoid any serious faults (bending of the shaft, impeller break-away, etc.).

2.4 Measuring RPM by the Tachometer

2.4.1 Set up instrument and measuring RPM

Apply reflecting tape or mark on the shaft which rotation frequency should be measured. The mark should be contrast against the shaft material (a light mark - on the dark

background, a dark mark – on a light background).

Reflective marking should not less than 20 mm length on shaft for tacho sensor to take speed reading.

Place the tachometer so that you follow the recommendations on positioning away from the measured object. Select the location of the tachometer that will provide the reliable and stable response from the mark. It is recommended to place the tachometer at the angle different from 90 degrees and 10-20cm away to the mark surface – this will decrease fault response from the surface of the shaft surface. Use retro-reflecting tape as a mark. (It is possible to use the correction fluid “Stroke” to apply the mark).

2.4.2Measuring RPM by the Tachometer

- Press ⏻ to turn on BT-77, press ⇩ key to switch display to Tachometer measurement mode shows in Fig-2.7a.

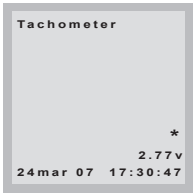


Fig-2.7a

Fig-2.7b

- Press 👍 two times to start rpm measurement.
- Press 👍 to record machine rotating speed and display RPM reading, Fig-2.7b.
- When finish measuring, press ▶☰ save result or press ↩ to return to program mode option when RPM noted.

3.0 ROLLER BEARING CONDITION MONITORING BY THE SHOCK PULSE METHOD (MEAUREMENT METHOD)

3.1 What is Shock Pulse Method (SPM) and it basis

Designation of the Shock Pulse Method (SPM) is a signal processing technique used to measure rolling bearing condition and the quality of their lubrication in the motor, pumps, separators, turbo compressors for diesel boost, etc. Using the instruments to measure shock pulses, one can determine the air or gas leaks via looseness in the high-pressure vessels or pipes. The research work conducted at Central Research & Design Institute of Navy allowed expanding the performance capabilities of the instruments. Shock pulse checkers have set to be used for the evaluation of condition of high-pressure fuel pumps, diesel injectors, valves of piston compressors.

The Shock Pulse Method (SPM) was developed by a Swedish instrument company and based on monitoring and analyzing of high frequency compression (shock) waves caused by mechanical impact. Acceleration of material particles generates pressure or shock wave that propagates as ultra-sonic frequency band through the object. In the initial phase of impact, the acceleration of material particles depends on impact velocity and is independent of the mass of colliding objects. Within short period and there is no evident deformation. The value wave shock is the impact velocity of colliding objects. In the second phase of the collision, the surfaces of two objects are deformed; the energy movement declines the object and generates vibrations that are diagnosed by the vibration analysis.

Piezoelectric transducer is used to measure shock pulse; vibration and noise background do not effect on it. The transducers electrically and mechanically tune to 28…32 kHz. Shock wave caused by the mechanical impact generates the decaying shock vibrations in transducer. The maximum magnitude of this decaying vibration is relative to the velocity of the impact (v). Since the decaying transient is well defined and has constant decay value, it

can be easily filtered out all other vibrations, i.e. vibration frequencies. The shock pulse method involves monitoring and analyzing the decaying transient process.

3.2 How Shock Pulse Measured and Evaluated for Rolling Bearing

The outer raceways of the bearing always feature roughness. Therefore a bearing under normal operating undergoes the mechanical impacts and creates shock pulses. Shock pulse value is dependent on the bearing surface condition and the peripheral condition of the bearing. Shock pulse value of the regular bearing features 1000 times increase since the time a bearing is new up to the moment when a bearing needs replacement. Because of the very large dynamic range shock pulses are measured on a decibel scale.

Empirical tests showed that even the new and lubricated bearing generates shock pulses. The value of this initial impact is set as dB_i (dB, initial value). As the bearing wears, the value dB_a (average shock pulse value) increases. Normalized value dB_n for the bearing can be shown as follows $dB_n = dB_a - dB_i$

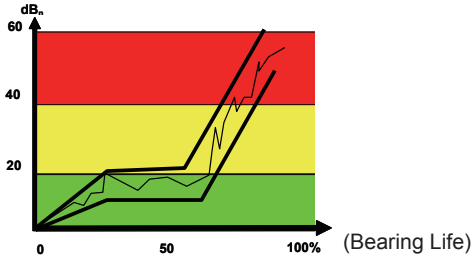


Fig-3.1. depicts dBn and bearing life ratio.

In order for the shock pulses reading to be quickly and easy to evalutated on the bearing condition, in simple understanding scale dB_n has been derived. It categories the bearing condition into three different zones by indicating the extent of bearing damage from good to poor condition, Fig-3.1:

dB_n	<	20	Good condition
dB_n	=	20 - 40	Satisfactory condition
dB_n	>	40	Poor condition (i.e. bearing need replacement)

Table-3

3.3 Evaluation of Bearing Condition with BT-77

Technical condition of the bearing is mainly determined by the level and relation of two measuring values dBm and dBc.

dB_m - maximum value of normalized signal in decibel.

dB_c - carpet value of normalized signal in decibel (background of the bearing).

However, under the work of the bearing the peak strikes have not only varying magnitudes, but frequencies as well. Fig-3.2 shows the typical examples of the evaluation of bearing condition and operating conditions (installation, roller bearing fit, alignment, lubrication) based on the relation of shock magnitude value (reading of scale dB_c) and frequency value (number of shocks per minute):

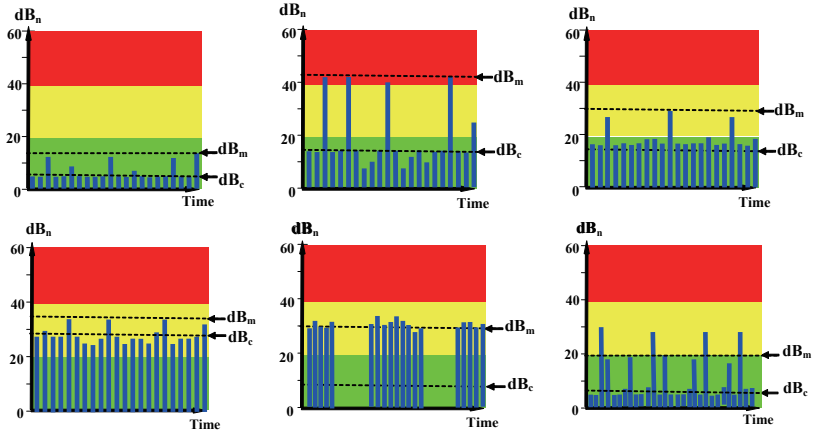


Fig-3.2

1. Good bearing generates mainly shocks in the interface between the loaded rolling element and the raceway. These shocks create normal background level with low carpet value (dB_c < 10) and random strikes with maximum value dB_m < 20 dB.

2. When the defects occur on the outer raceway of a bearing or a bearing element, the general background features peak signals with Max Value dB_m > 40 dB. The collisions happens randomly, quite often their carpet values stand within the limits dB_c < 20 dB. Though when the bearing failure occurs, the carpet value can be decreased. As a rule, a great difference between dB_m and dB_c values occurs.

3. When there is no lubrication supply or tight (loose) roller bearing fit, the Carpet Value will reflect this by increasing (dB_c > 10), even there are not any defects on the outer raceway of a the bearing. The Max Value and the Carpet Value are relatively close (dB_m = 30, dB_c = 20).

4. Under pump cavitation both backgrounds feature high magnitude value. Shock pulse standards on pump cavitation are published. The measurements are taken on the pump case. Be aware that the curved surfaces damp shock pulses out of cavitation. The difference between the Max Value and the Carpet Value is quite small (for example, dB_m = 38dB, dB_c = 30 dB).

5. Mechanical contact between the rotating and stationary parts of the mechanism next to the bearing create rhythmic (periodic) a high amplitude burst of Shock Pulse waves.

6. If the bearing undergoes the shock load, for example, as the result of piston stroke in the compression pump, the shock pulses will be rhythmic (periodic) with respect to the operating mode of the machine, so the Carpet Value (dB_c) and the Max Value (dB_m) are easily defined.

Driving gear failure in the gear box also can cause the periodic strikes. These strikes will be rhythmic in respect to the shaft speed (on all bearings installed in the gear box). Don't take measurements when you start the motor or you just applied the lubrication (complete it in 15 minutes).

Table-3.2 shows mentioned above and other possible cases of increased values of shock impulses. It may happen that a new bearing may have the Carpet Value dBc more than 20 dB. If these values are stable within some time interval, bearing condition is acceptable.

3.4 Method and measurement location of the bearings

Shock pulse measurements should be completed on the bearing housing. When free access to the bearing housing, use the measuring probe as shown in Fig-3.3a, 3.3b 3.3c and Fig-3.3d.

Before shock pulse measurement it may be necessary to consult design drawings to see how the machine is constructed and check the measuring points based on signal path. The surface at the measurement point should be plane. If the paint layer is thick, clear off paint on measuring spot. Fit the probe radically to the checked surface.

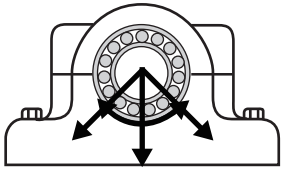


Fig-3.3a Bearing load emission window (load Zone)

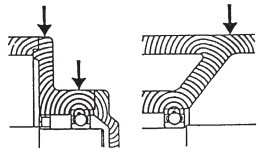


Fig.-3.3b. Shock pulse zones.

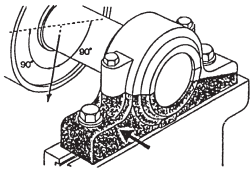
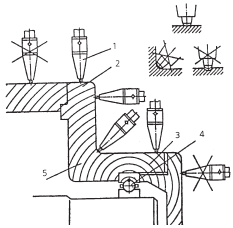


Fig-3.3c Shock pulse zones.



1 - Vibration measuring probe
2 - Bearing housing
3 - Stress wave propagation
4 - Defective rolling bearing
5 - Shock pulse measuring zones (Bearing load zone)

Fig-3.3d

4.0 Delivery Set

№	Description	Qty	Note
1.	BT-77 w/ rechargeable battery inserted	1	
2.	Bearing Vibration measuring probe	1	
3.	IR Tachometer w/ mounting stand	1	
4.	AC Charger, 220-230Volts	1	
5.	Liquid maker	1	
6.	Carrying Case with Foam-insert	1	
7.	Operating Instructions Manual in CD-ROM	1	
8.	CD-ROM PC software	1	
9.	USB PC communication cable	1	
10.	Maker calibration certificate	1	

Table 4.0

КонТест