RMT Ltd

THERMOELECTRIC MATERIAL EXPERT

DX8080
USER GUIDE

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Limited Warranty

RMT Ltd warrants that the DX8080 Device, if properly installed and used, will be free from defects in material and workmanship and will substantially conform to RMT's publicly available specification for a period of one (1) year after the date that the DX8080 Device was purchased.

If the DX8080 Device, which is the subject of this Limited Warranty, fails during the warranty period for the reasons covered by this Limited Warranty, RMT, at this option, will:

REPAIR the DX8080 Device; OR

REPLACE the DX8080 Device with another DX8080 Device of the same model.

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CONTENTS

1. INTRODUCTION

The given User Guide is to provide thorough information for studying and handling the **Thermoelectric Material Expert** model **DX8080** (for brevity further can be referred to as the **DX8080**). The **DX8080** is developed for laboratory testing of thermoelectric (TE) properties of the n/p-type material based on Bi_2Te_3 when measuring pellets.

These properties are the Seebeck coefficient α, electrical conductivity σ, figure-of-merit Z, thermal conductivity κ (the latter is calculated).

Measurements are automatical with a given temperature interval. In a measuring point the steady state temperature is achieved. Three samples are tested simultaneously. Data telemetry output, data processing, results storage are enabled. Corrections for heat exchange along leading wires are calculated.

The tests allow applying the results to the most complete quality control of TE material and to the mathematical simulation of TE modules.

2. TECHNICAL AND OPERATIONAL DESCRIPTION

The facilities are developed for measuring the Seebeck coefficient α, electrical conductivity σ, figure-of-merit Z, calculating thermal conductivity κ within 220 – 400 K. The tests are performed in vacuum at a given ambient (sample) temperature.

The ranges of the parameters measured by the **DX8080** are given in the table.

Measured parameter	Designation	Units	Range	Accuracy, %
Seebeck coefficient	μV/K	α	100…300	3.5
Electrical conductivity	1/(Ohm·cm)	σ	300…2000	5
Figure-of-merit	1000/K	Z	0…4	7

For the tests, several material samples can be connected in parallel. The samples or their assemblies should meet the following dimensional requirements.

Parameter	Units	Min	Max
Sample length	mm	1	5
Sample cross-section	mm^2		3x3
Length to cross-section ratio	mm^{-1}	0.5	1

The samples should be prepared for the tests. The preparation procedure is described further. The prepared samples are soldered on the sample holder by thin (diameter 0.075 mm) copper and constantan wires. Up to three samples can be soldered on the holder. The sample holder is then put onto the vacuum table closed by the cover. Gas is pumped off by the pumping system and its control block. A measuring cycle is then started.

The device works under a PC control by special software. The software commands are processed by the control block.

The **DX8080** appearance

3. TECHNICAL DATA

Technical data of the facilities **DX8080** are given in the table.

Parameter	Designation	Value	Accuracy	Resolution
Thermostabilizing surface temperature	T	220…400 K*	±1 K	0.01 K
Sample temperature	T_s		±1 K	0.01 K
Voltage	U	0.4-2.0 mV	± 3.5 μV	0.1 μV
Electrical current (AC and DC)	I	5-100 mA	± 30 μA	1 μA
Vacuum, not worse than		$5 \cdot 10^{-3}$ mm Hg		
Number of samples measured simultaneously		3		
Current and probe wires length		15 mm		
Constantan wires diameter		0.05-0.08 mm		
Current and probe wires diameter		0.05-0.08 mm		

*At temperature 293 K.

Electric power consumption:

- AC voltage, - 220V +10/-15;
- Power consumed – not more than 500 W.

The equipment **DX8080** is meant for laboratory measurements at the ambient temperature 25±3ºC and relative humidity up to 80%.

4. STANDARD KIT

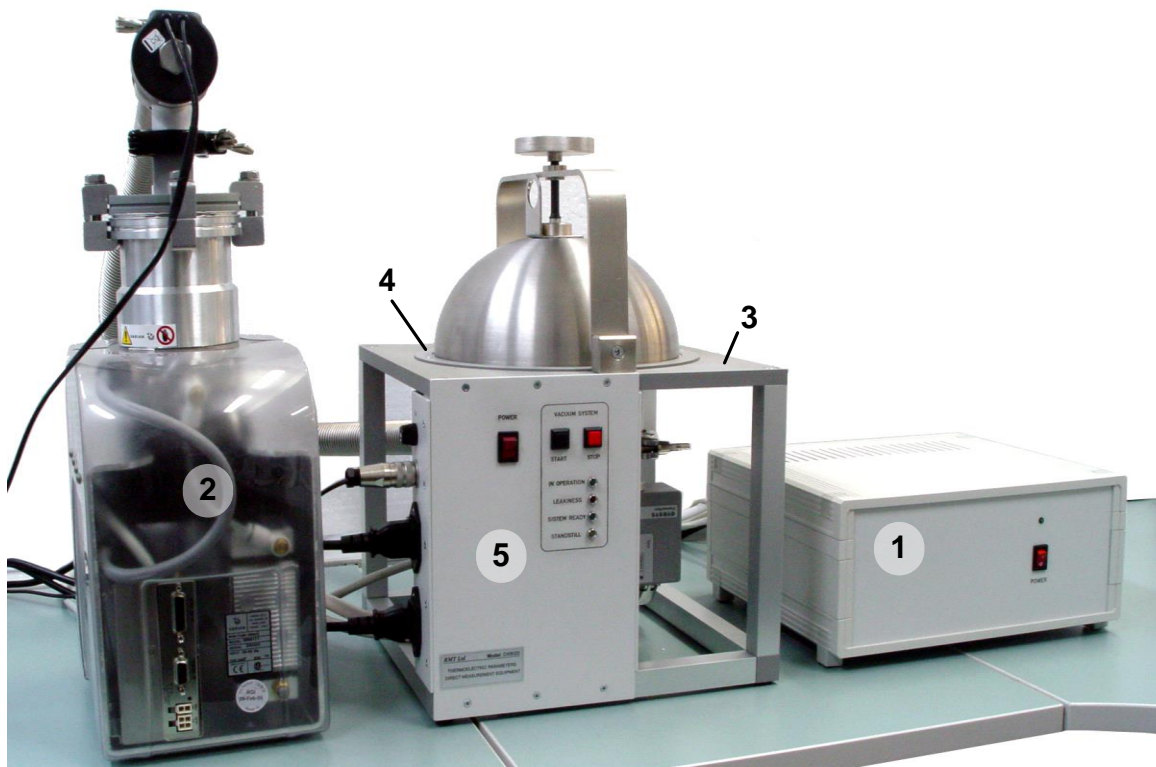| #	Name	Note
1	Control block	PMTK 250.08.00
2	Vacuum station	ASM 110 TURBO
3	Vacuum table with mounted:	PMTK 250.09.00
4	Samples holder	PMTK 250.02.00
5	Vacuum system control block	PMTK 102.14.00
6	Control cable of the samples holder	
7	Supply cable s of the samples holder	
8	Thermoelectric cooler TEC1 supply cable	
9	Fan supply cable	
10	USB cable	
11	Power cord for computer	
12	Power cord for computer	
13	Power cable computer-monitor	
14	Vacuum pipe	

For operation, a computer with the software installed is necessary.
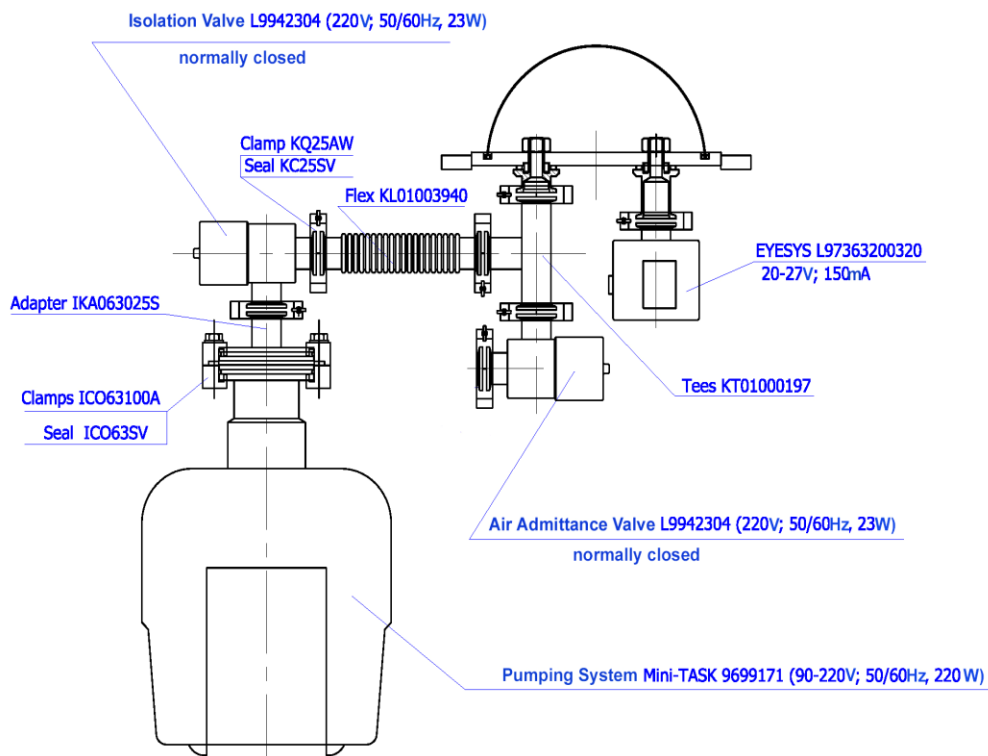
5. ARRANGEMENT AND OPERATION

Item designations in the figures correspond to item designations given in Section 1.2 "Standard Kit".

Further in the text of a designation in brackets correspond to the designations in figures.

- The measuring part of the device represents a vacuum table (3), with the basis thermally stabilized on which the sample holder is located.

- The basis temperature is stabilized by a TE module with power supply controlled.

- The heat rejection from the hot side of the module is carried out by the electrical fan CNPS7000A-Cu.

- The vacuum-tight connectors «Lemo» carry out the lead terminals.

- The vacuum chamber is closed by the cover, which is held down to the ring gasket.

- The pumping is accomplished by the pumping system Mini-TASK (see the vacuum station scheme) via the inlet pipe.

- Residual gases level is controlled by the vacuum pressure gauge EYESYS ConvecTorr or by the thermocouple lamp 531 and controller 801.

- The **DX8080** control and signals processing is fulfilled by the control unit with the help of the software «**The DX8080 Operation Program**». The measuring methods and mathematics are described in Chapter 4; all the necessary information on the **DX8080** Software is offered in Chapter 5.

Vacuum Table Scheme

Isolation Valve L9942304 (220V; 50/60Hz, 23W)
normally closed

Clamp KQ25AW
Seal KC25SV

Flex KL01003940

EYESYS L97363200320
20-27V; 150mA

Adapter IKA063025S

Clamps ICO63100A
Seal ICO63SV

Tees KT01000197

Air Admittance Valve L9942304 (220V; 50/60Hz, 23W)
normally closed

Pumping System Mini-TASK 9699171 (90-220V; 50/60Hz, 220W)

5.1. Connection Procedure

- Connect the vacuum pipe (14) to appropriate flanges of the vacuum table (14a) and vacuum station (14b). Thus it is necessary to weaken fastening by the wing and to remove the appropriate collar. After that, connect the pipe to the flange, having put a spacer into a joint. Establish a collar and pull the junction together by tightening the wing.

- Connect the vacuum system control block (13a) to the vacuum station (13b) by the computer-monitor power cord (13). Turn on the switch of the vacuum station (as in the figure).

- Connect the cable going from the valve of the vacuum station (15a) to the vacuum system control block (15b).

- Turn off the switch "POWER" on the forward panel of the vacuum system control block (5). Connect the power cord (11) to the vacuum system control block (11a).

- Connect the cable of the control of the samples holder (6) to the control block (6a "SIGNALS") and to the vacuum table (6b). There are 20-contact sockets on both ends of the cable.

- Connect the power cable of the samples holder (7) to the control block (7a "THERMOSTAT 2 ") and to the vacuum table (7b). There are 8-contact sockets on both ends of the cable.

- Connect the power cable of TEC1 (8) to the control block (8a "THERMOSTAT 1") and to the vacuum table (8b). There are 4-contact sockets on both ends of the cable.

- Connect the power cable of the fan (9) to the control block (9a "FAN") and to the vacuum table (9b). There are 2-contact sockets on both ends of the cable.

- Connect the cable (16), from the vacuum station control block to the control block (16a "Vacuum station").

- Turn off the switch "POWER on the forward panel of the control block (1). Connect the power cord (12) to the control block (12a).

- Connect the plugs of the power cords (11) and (12) to the sockets of the alternating current network ~220V (50Hz).

- Connect the control block (10a) and computer by the USB cable (10).
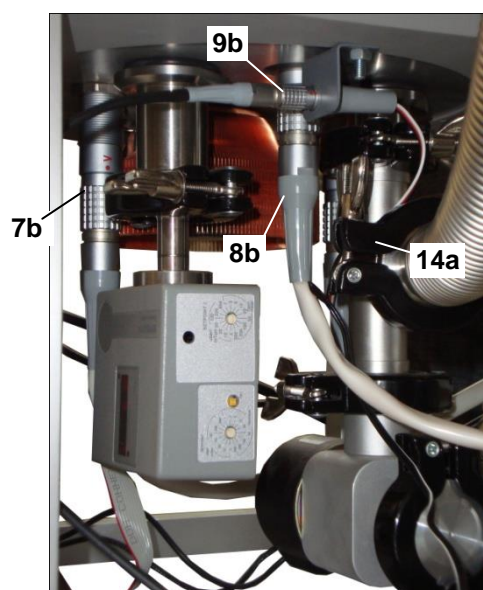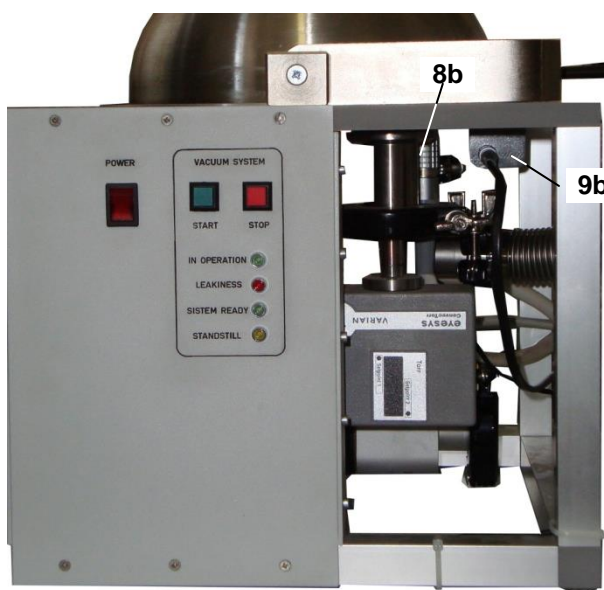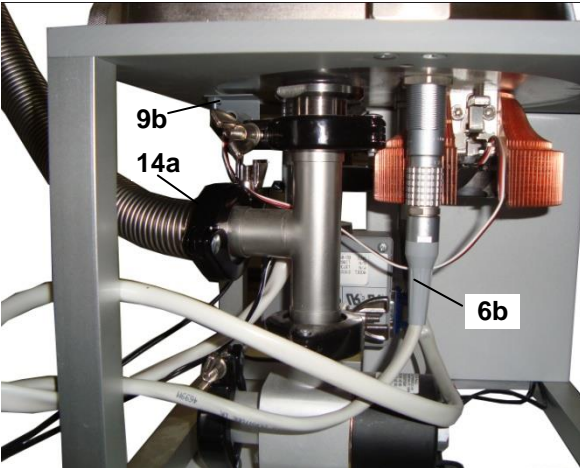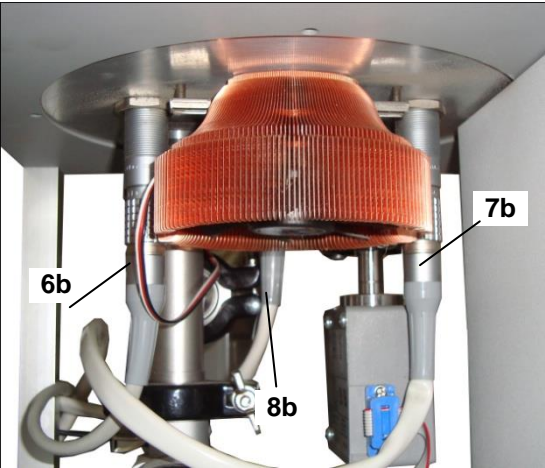
5.2. Samples Preparation

Before the measurement starting, the samples should be prepared in an appropriate way.

- A sample is made of the material ingot. The sample length should be within (1...5) mm. The ratio of the sample length to its area of cross-section should be in a range (0.5...5) 1/mm. The sample face surfaces should have a standard metal covering (final layer is 3-5 μm Ni).

- Concentrators are made of 0.5 mm thick cooper sheet. Its area should surpass the sample cross-section no more than by 75 %.

- The concentrators are soldered to the face surfaces of the sample, to each of which two copper wires are soldered Ø0.08 mm, 40±2 mm long as well as a constantan wire Ø0.075 mm, 40±2 mm long. It is necessary to provide an arrangement of wires similar to that shown in the figure.
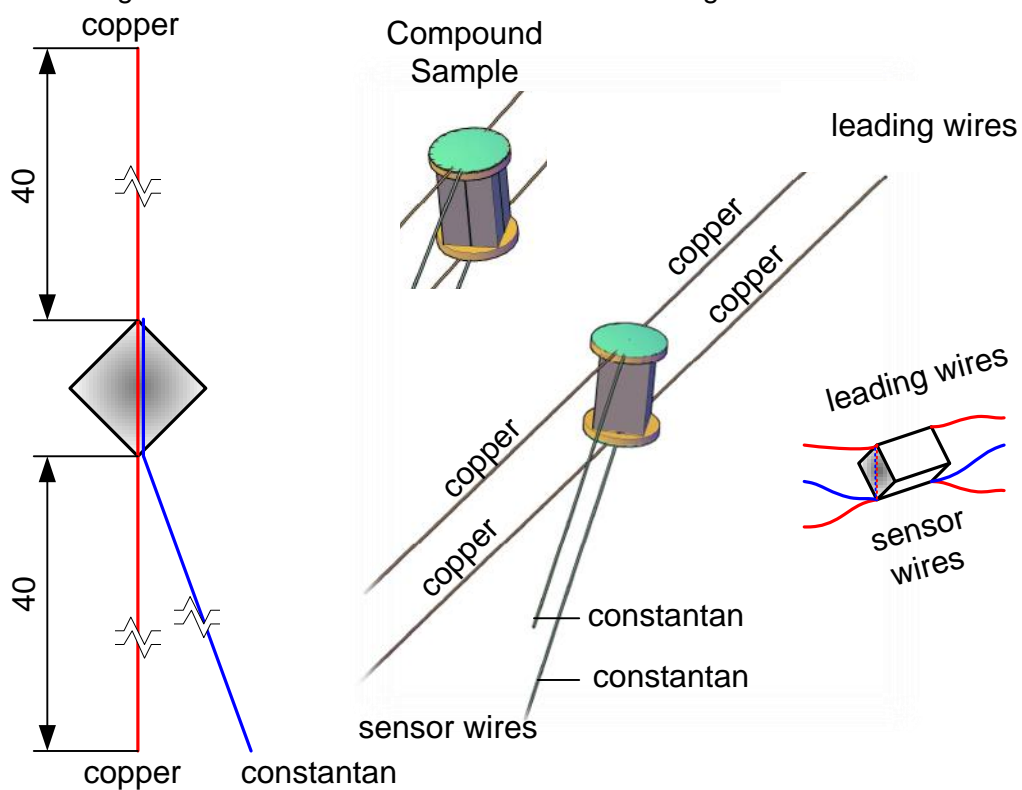
- Solder melting temperature is no higher than 100ºC.

- It is acceptable to simplify the installation procedure, first to solder the wires to the concentrators by a high-temperature solder (for example, solder with melting temperature 230 ºC), then to solder the concentrators with the wires to the sample by a low-temperature solder (for example, solder with melting temperature 110ºC).

- It is acceptable to use a compound sample if meeting all the above-said requirements on the sample dimensions.
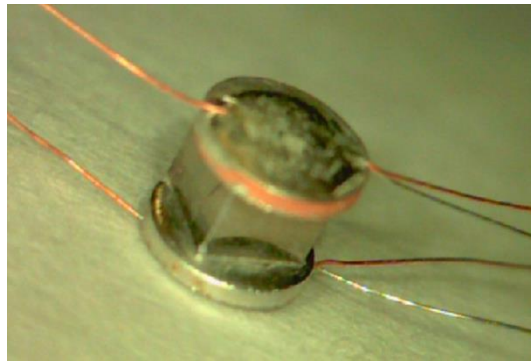
Sample 2 x 2 x 1.6 mm^3 with concentrators
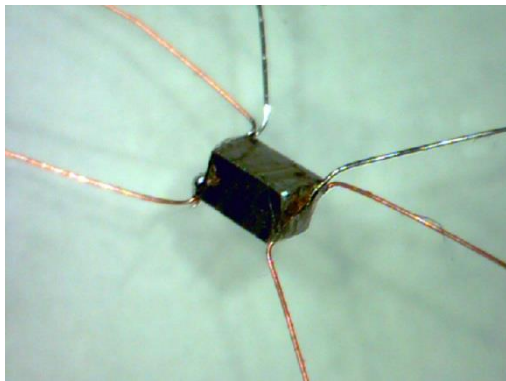
Sample 1 x 1 x 1.6 mm^3
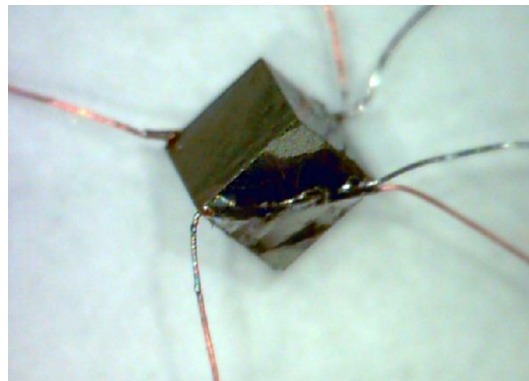
Sample 2 x 2 x 1.6 mm^3

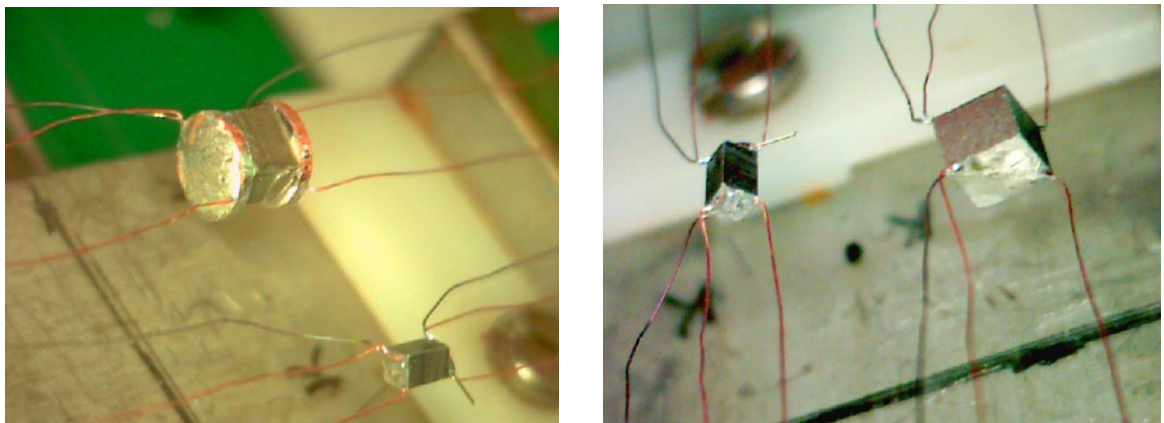## 5.3. Samples Mounting onto the Samples Holder

The samples prepared for the installation are mounted onto the samples holder as follows:

- Arrange a sample on the centre between assembly circuit boards as specified in the figures.

- Solder the wires from the sample to the circuit boards, solder Sn-63%, Pb-37% (melting temperature 183ºC), colophony flux. Mind the proper sequence of the wires.

- Solder the wires ends to the contacts of the main board, solder Sn-63%, Pb-37% colophony flux, cut the redundant ends.

- Mount the rest of the wires similarly.

- Straighten the wires, eliminating their mutual contact and a contact of metal parts.

- Establish screens, after greasing the surfaces by vacuum greasing.
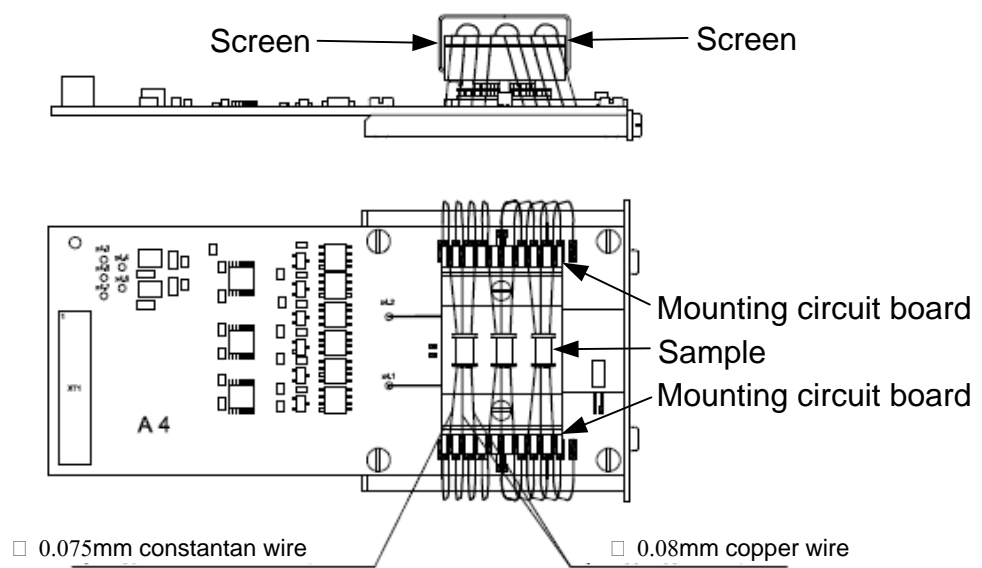
The prepared samples are mounted onto the sample holder:

The samples holder with the samples mounted (no screen):
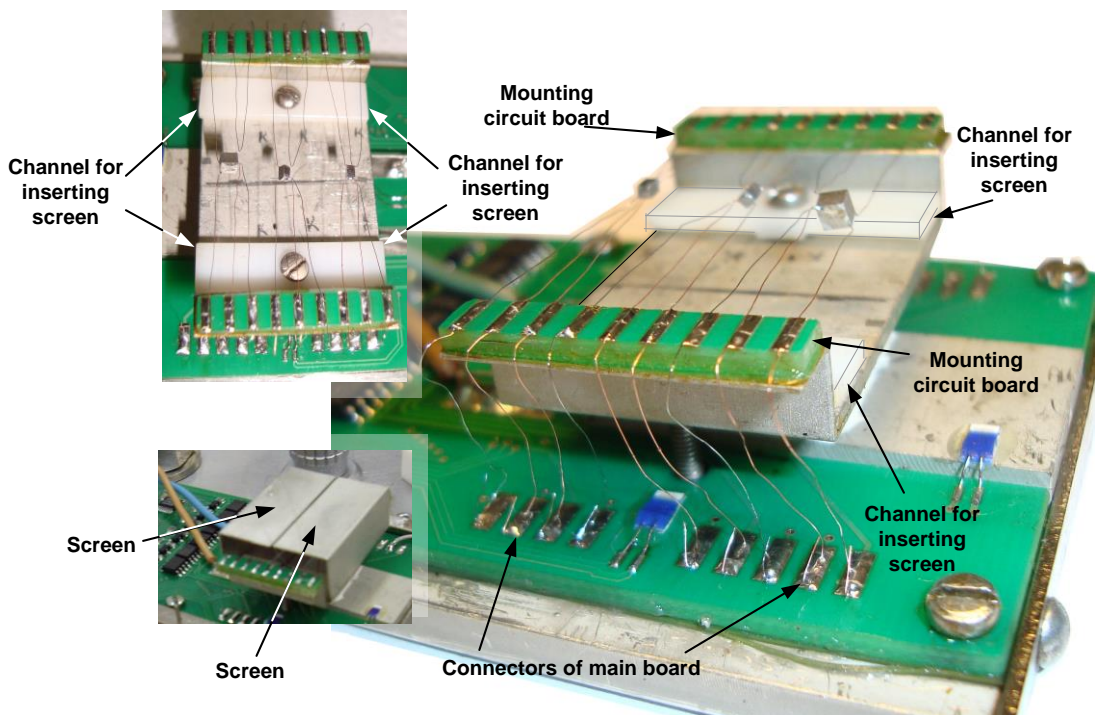
The correspondence of numbering of samples and installation positions is given in figure below:
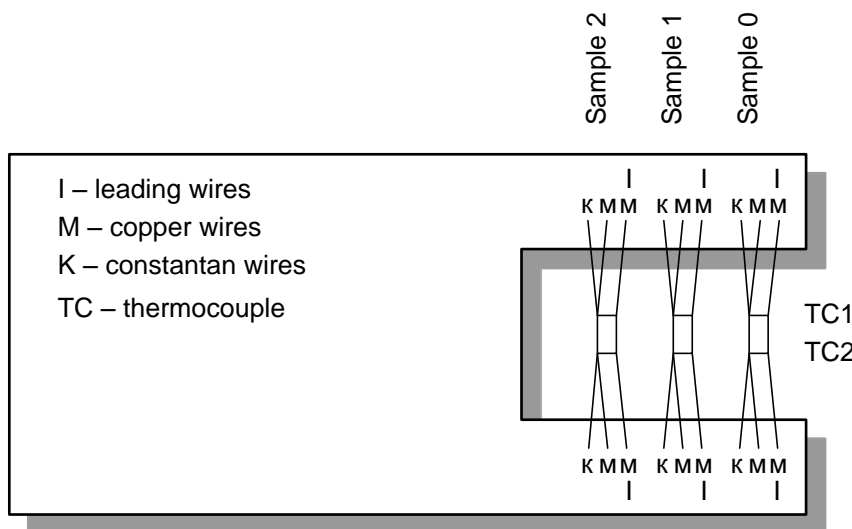
After the installation of the samples, the samples holder is inserted into the fastening guides of and is connected to the vacuum-tight sockets of the vacuum table. Before that, to improve the thermal contact, it is necessary to grease the bottom of the metal plate of the samples holder and connecting surfaces by the silicone grease.

The process of connection is illustrated in the figures below:
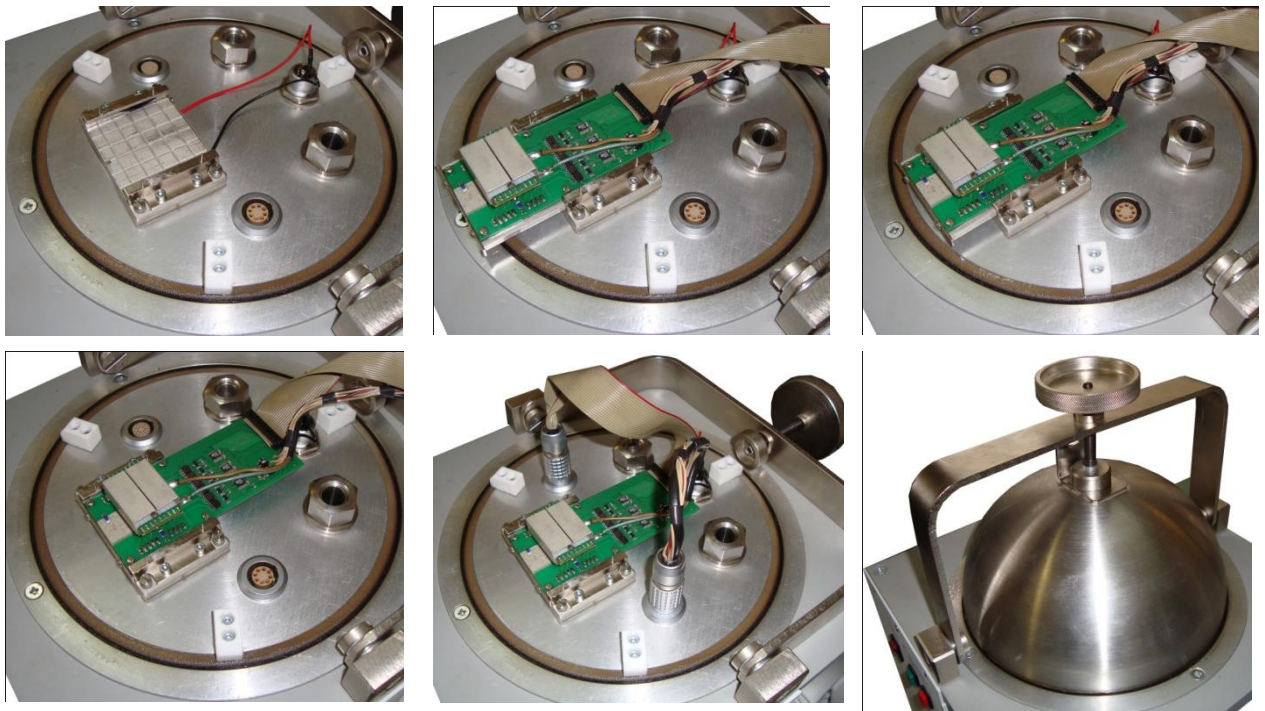
After the installation and connection of the samples holder, the cover should be closed. It is necessary to grease the edges of the cover by the vacuum grease. Close the table by the cover and press it to the gasket by the hold-down.

5.4. Vacuum Station Control

The vacuum station should be connected to the vacuum system control block and to the vacuum table as described above.

5.4.1. Vacuum Station Turning On

- Switch on the vacuum station control block "POWER", which takes place on the forward panel of the vacuum system control block (the green lamp blinks "IN OPERATION").

- Press and let off the button "START" on the forward panel of the vacuum system control block (the green lamp " IN OPERATION " is on). The vacuum station starts pumping out gas from the closed volume of the vacuum table. In this volume (under the cover) it is possible to observe the pressure on the indicator of the gauge of residual pressure "Eyesys ConvecTorr"

Residual pressure gauge

- If after 3.5 min the red lamp "LEAKINESS" is on, there is a leak in the volume. In this case, the control block stops the vacuum station Mini-Task. The next switching on is possible in 8 min. Remove a leak in the vacuum system.
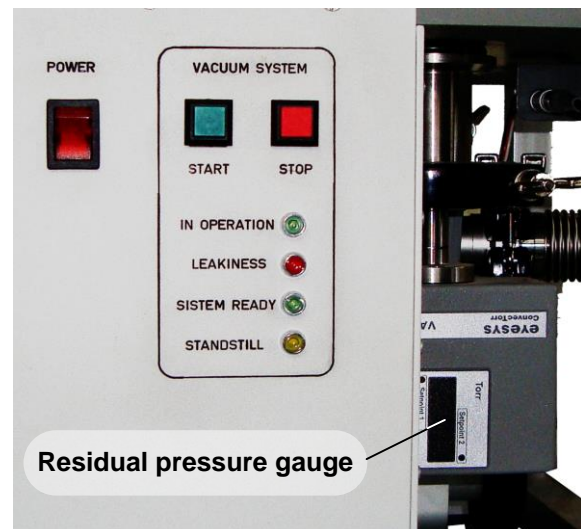
- On the chamber pressure reaching 5×10^{-3} mm Hg the green lamp "SYSTEM READY" is on and the equipment is ready for measurement. In addition, the sound signal indicates the necessary vacuum level.

Important!!! During the operation of the vacuum station some of its parts are heated up. It should be taken into account in order to prevent burns.

5.4.2. Vacuum Station Turning Off

- After the measurements, press and keep pressed the button "STOP" till the characteristic click when the vacuum crane on the vacuum station Mini-Task (crane 1) is closed and the electromagnetic valve (crane 2), equalizing the pressure in the chamber with atmospheric pressure opens.

- The yellow lamp "STANDSTILL" is on, The next switching on of the vacuum station is possible in 8 min by the button "START" after the yellow lamp "STANDSTILL" is off.

Important!!! To prevent a damage of the vacuum station do not switch off the control block of the vacuum system by the switch "POWER" while the yellow lamp "STANDSTILL" is on.

6. MEASURING PROCEDURE AND CALCULATING METHODS

- Prepare the samples according to Section 5.2

- Mount the samples onto the samples holder. Establish the samples holder onto the vacuum table according to Section 5.3.

- Switch on the vacuum station and pump out the system to the pressure less than 5x10-3 mm Hg according to Section 5.4.

- Switch on the control block and perform the measurements by the methods – see Section 6 MEASURING PROCEDURE AND CALCULATING METHODS and by the software – see Section 7 SOFTWARE.

- After the measurements are over, switch off the device, the vacuum station and pump air in the chamber according Section 5.4

6.1. Measuring Procedure

The measuring procedure is the following:

1) Measure the dimensions of the samples.

   Important!!! Mind the recommended ratio $0.5 < L/s < 5$ [mm^{-1}] – see 5.2

2) Prepare the samples for the measurements as shown in Section 5.2 .

3) Mount the samples and wires as shown in Section 5.3.

4) Close the chamber and pump out air from the chamber down to residual pressure less than $5 \cdot 10^{-3}$ mm Hg – see Section 5.4.

5) Install the software «DX8080 Application» - see Section 7.1.

6) Set the required parameters of the samples and wires.

7) Set the test temperature (or temperature range and a step) – see Section 7.5.

8) Set the measurement current. Below see the preliminary table for allowable ratios L/s and wires at 300 K:

L/s, мм$^{-1}$	I, мА
0.5	100
1.0	60
1.5	40
2.0	30
3.0	25
4.0	20
5.0	15

9) Start the measurements – see Section 7.6

The further measurements are performed automatically. Here we give the procedure for testing at 1 temperature point.

10) The table temperature is stabilized for the level desired.

11) The samples are exposed for DC current *I* of the set value and of *a certain direction.*

12) In the stationary mode the following values are measured and stored:

- - Sample voltage (*U*),
- - Temperature T_1 on one end of the sample,
- - Temperature T_2 on the other end of the sample,
- - Electric current value.

13) The samples polarity is defined. Suppose $\Delta T_s = T_2 - T_1$ is the sample temperature difference along the current direction (see the figure). If $T_1 > T_2$, the sample is n-type.
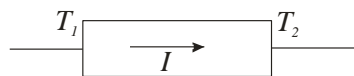
14) The DC current of this direction is off.

15) The DC current of the opposite direction is on (-*I*). The measurements of item. 12) are repeated

16) The DC current of this direction is off.

17) AC current of the same value *I* is on.

18) The following values are measured and stored:

- - Sample voltage (U_R),
- - Temperature T_1 on one end of the sample,
- - Temperature T_2 on the other end of the sample,
- - Electric current value.

19) Each sample AC resistance is calculated by U_R (see Section 6.2):

20) Electrical conductivity of each sample material σ is calculated (see Section 6.2):

21) Each sample Seebeck coefficients α is calculated for each polarity of the current and is then averaged (see Section 6.2):

22) Each sample figure-of-merit Z is calculated for each polarity of the current and is then averaged (see Section 6.2).

23) Each sample thermal conductivity κ is calculated (see Section 6.2):

24) By the value κ the correction for thermal conductance of leading and probing wires is calculated and taken into account in Z (see Section 6.2):

25) A corrected value of κ is calculated.

26) The results are stored.

After the tests are over:

27) Turn off the device and vacuum station as described in Section 5.4.2.

6.2. Calculations

The formulae for the calculations of the values α, σ, Z are as follows:

1) AC resistance *R* of a sample is calculated as:

$$R = \frac{U_R}{I},$$ (1)

where U_R is sample AC voltage for the current *I*.

2) Electrical conductivity σ of TE material is estimated as:

$$\sigma = \frac{L}{Rs},$$ (2)

where *L* is sample length, *s* is area of sample cross-section.

3) Sample Seebeck coefficient α is given by:

$$\alpha = \frac{U_\alpha}{\Delta T},$$ (3)

where $U_\alpha = U - U_R$, *U* is sample DC voltage for the current *I*, $\Delta T = T_2 - T_1$, T_1, T_2 are temperatures on sample ends.

4) Material figure-of-merit Z is calculated as:

$$Z = \frac{U_\alpha}{U_R \overline{T}},$$ (4)

where $\overline{T} = \frac{1}{2}(T_1 + T_2)$.

5) Material thermal conductivity is calculated as:

$$\kappa = \frac{\alpha^2 \sigma}{Z}$$ (5)

6) The correction *A* for thermal conductance of leading and probing wires $\sum K_w$ is obtained as:

$$A = 1 + \frac{\sum K_w}{2K_s} = 1 + \frac{\kappa_w s_w L}{L_w \kappa s},$$ (6)

where $K_s = \kappa \frac{s}{L}$. The subscript *w* refers to the copper wires. Thermal conductance of a constantan wire is ignored.

7) By Eqs. (5) and (6) the corrected value of figure-of-merit is calculated:

$$Z = \frac{U_\alpha}{U_R \overline{T}} A \qquad (7)$$

8) For the corrected value Z the corrected value of thermal conductivity is estimated (5).
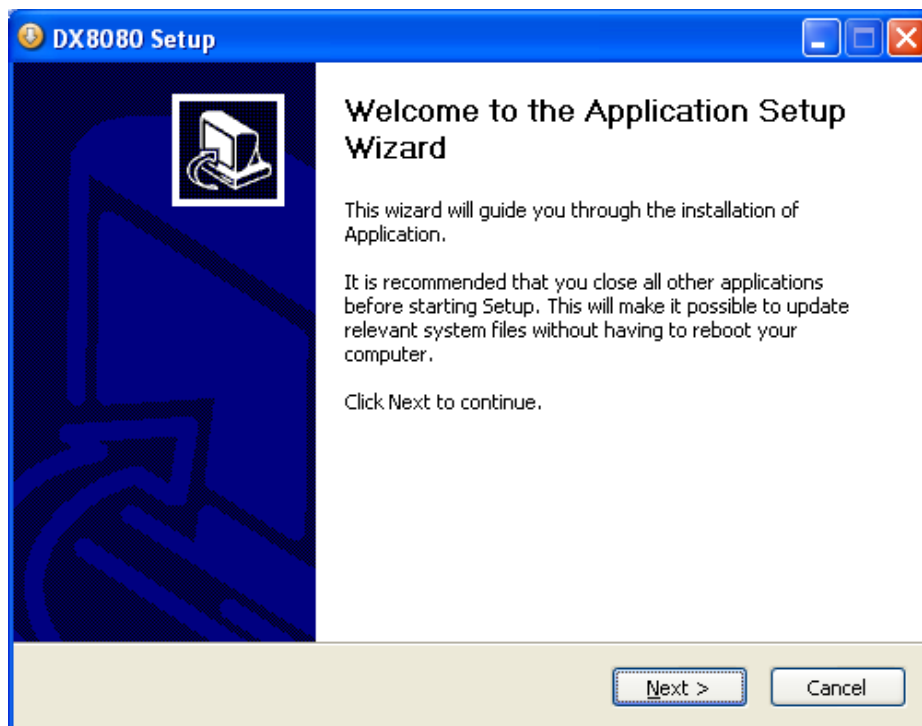
7. SOFTWARE

7.1. Software Installation

Important!!! It is necessary to install the software «DX8080 Application» before the connection of the device «DX8080» to a computer.

For a successful installation of the software, the computer should meet the following requirements:

- Processor – Intel Pentium, frequency 1.5 GHz or AMD Athlon and higher

- 512 Mb RAM

- Operating system Windows 2000/XP/VISTA

- 50 Mb of free space

- CD-ROM

If you install the software from the CD (it is supposed that the option of automatic loading is on) «Autorun»), press the button «DX8080 Application Setup». If you downloaded the software from the site (http://www.rmtltd.ru), run the file «<PATH>\Dx8080Setup.exe» and follow the instructions, where <PATH> is the path to the file-setup.
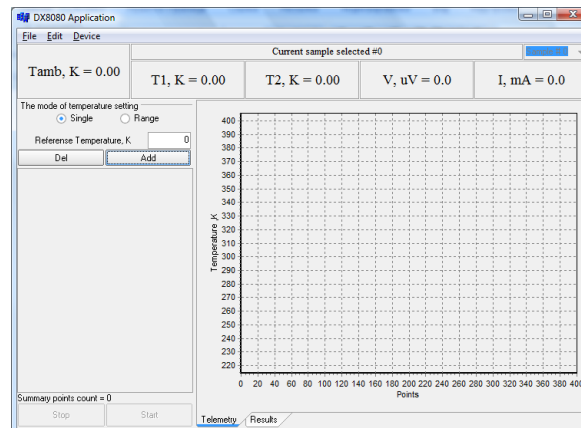

7.2. Connection with Device

Before start of the program, it is necessary to connect the device DX8080 to a personal computer. The connection is carried out by the cable USB (Type A - Type B).

The software is started in a usual way, by a double-click of the mouse on the appropriate tag. After a successful start, the main window of the program will appear

For the connection with the device choose a proper port, to which the device is connected, from the main menu «Device-Available Port».

If the list of ports is empty, it is necessary to check up connection of the device to a computer and its connection to the power supply. After that choose from the main menu «

Device-Available Port-Refresh » for updating the list of accessible ports.

If the connection with the device is ok, on the panel of the information will change the message « Device disconnected VACI ». In case of an unsuccessful, the message will appear:
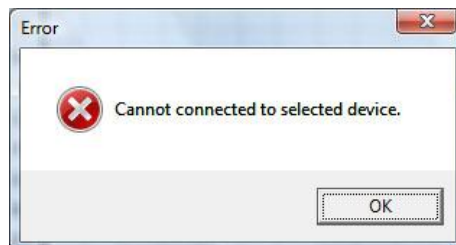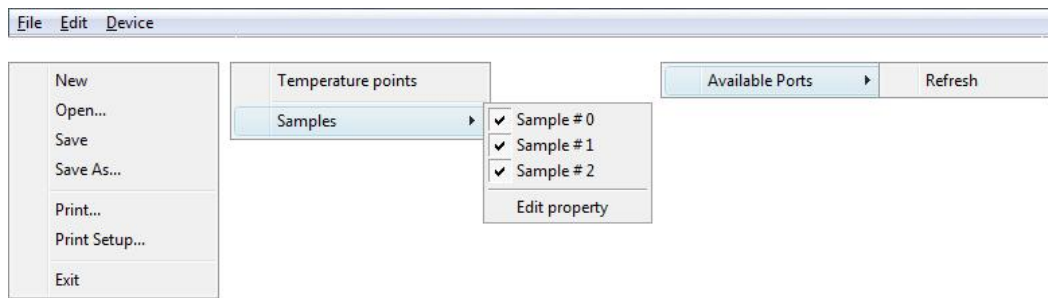

7.3. Software Main Window

The main window of the program consists of several functional areas of:

- Applications of the main menu

- Current parameters of the sample chosen

- Panel of setting temperature points

- Temperature points list

- Sample temperature plot

- Button of starting the procedure

- Informational panel

The structure of the main menu is given in the figure:

- «File»
  - «New» - creation of the new list of temperature points
  - «Open» - loading temperature points stored earlier
  - «Save»- temperature points storage
  - «Save As …» - storage of temperature points in a text form with tabulation
  - «Print» - printing temperature points
  - «Print Setup …» - printer settings
  - «Exit» - exit from the program

- «Edit»
  - «Temperature points» - results editing
  - «Samples»
    - «Sample 0» - sample 0
    - «Sample 1» - sample 1
    - «Sample 2» - sample 2
    - «Edit Property» - samples properties editing

- «Device»
  - «Available Ports» - ports discovered
  - «Refresh» - ports list update

Current parameters of a sample chosen.

	Current sample selected #0			Sample # 0
Tamb, K = 322.00	T1, K = 319.12	T2, K = 319.06	V, uV = 6.1	I, mA = 0.0

Current information about a sample chosen is displayed on the panel:
- Ambient temperature (K)
- Samples ends temperature (K)
- Sample voltage (μV)
- Sample current (mA)

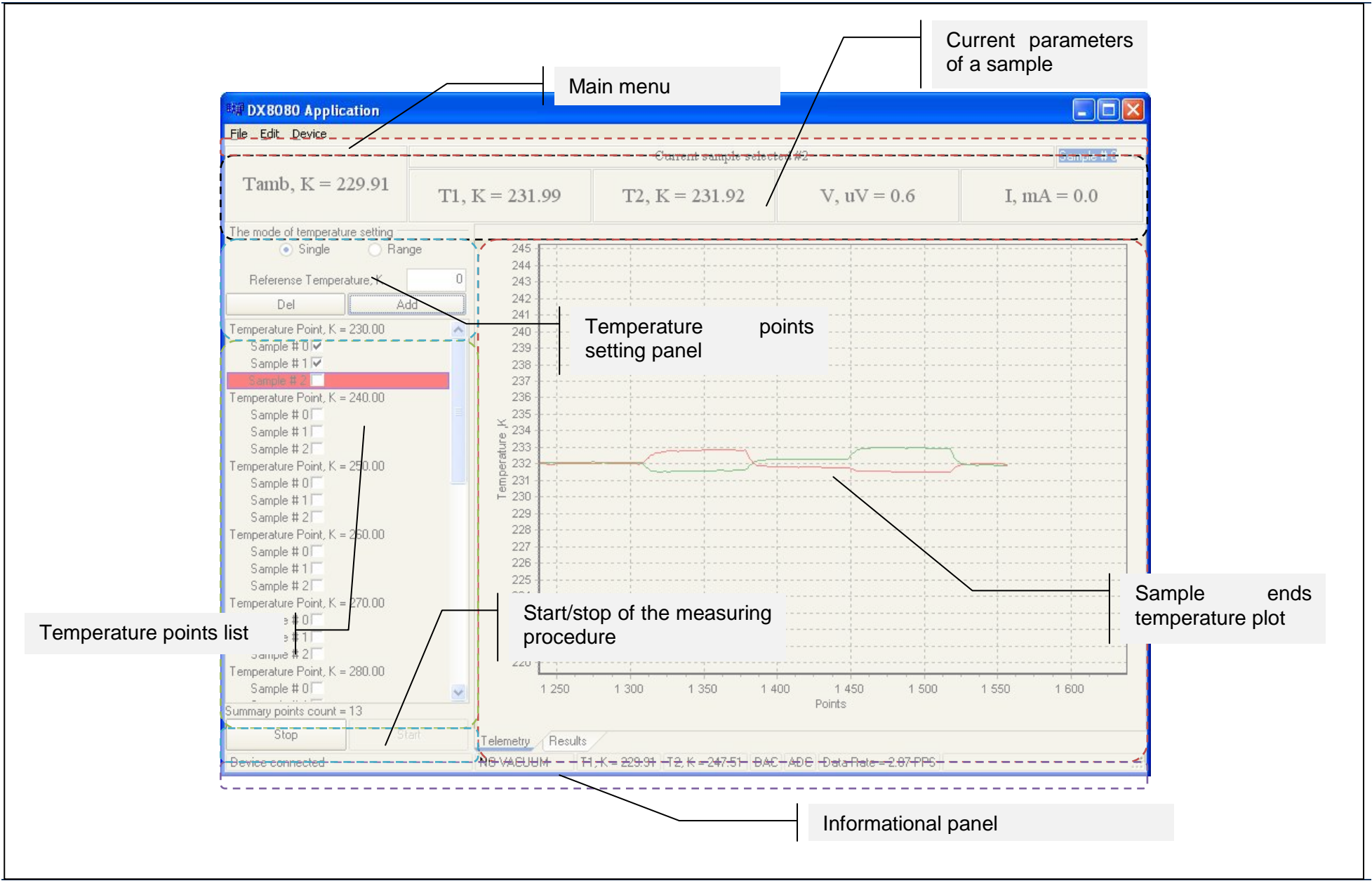The current sample is chosen from the drop-down combo box.

The panel of setting temperature points is described in more detail below.

The list of temperature points displays the list of temperature points and samples. If the sample is not measured yet, it is marked by an empty square. If measurements were completed, the sample is marked by a tick. If the sample is not used in measurements, it is marked by a cross.

The temperature [Kelvin] of the ends of the samples is plotted via time.

The following information is displayed on the informational panel:

- Device connection status

- Vacuum status

- Current temperature on TECs, which are responsible for the temperature setting

- ADC and DAC status

- Current rate of reading data from the device (points per second)

Current parameters of a sample

Main menu

DX8080 Application

File Edit Device

Current sample selected #2

Sample # 2

Tamb, K = 229.91   T1, K = 231.99   T2, K = 231.92   V, uV = 0.6   I, mA = 0.0

The mode of temperature setting

Single   Range

Referense Temperature, K   0

Del   Add

Temperature Point, K = 230.00
  Sample # 0 ☑
  Sample # 1 ☑
  Sample # 2 ☐
Temperature Point, K = 240.00
  Sample # 0 ☐
  Sample # 1 ☐
  Sample # 2 ☐
Temperature Point, K = 250.00
  Sample # 0 ☐
  Sample # 1 ☐
  Sample # 2 ☐
Temperature Point, K = 260.00
  Sample # 0 ☐
  Sample # 1 ☐
  Sample # 2 ☐
Temperature Point, K = 270.00
  Sample # 0 ☐
  Sample # 1 ☐
  Sample # 2 ☐
Temperature Point, K = 280.00
  Sample # 0 ☐

Summary points count = 13

Stop   Start

Device connected

Temperature points setting panel

Temperature points list

Start/stop of the measuring procedure

Sample ends temperature plot

Telemetry   Results

NO VACUUM   T1, K = 229.91   T2, K = 247.51   DAC = ADC   Data Rate = 2.07 PPS

Informational panel

7.4. Sample Parameters Setting

For setting sample parameters, it is necessary to choose «Edit-Samples-Edit property»in the main menu. The dialog window of setting sample parameters will open.
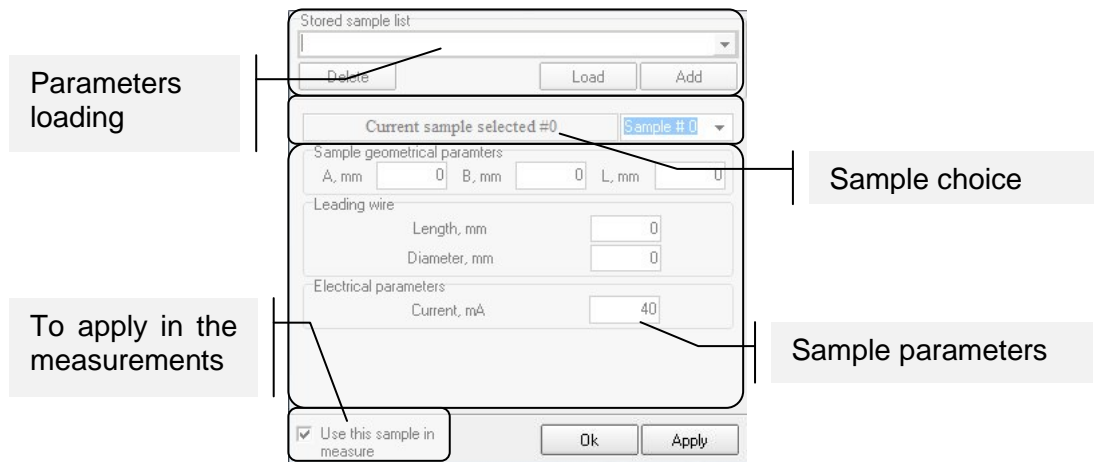
For measurements, it is necessary to set parameters of a sample, such as: width (A), height (B), length (L); Length (Lw) and diameter (Dw) of wires (the length is per wire). All geometrical parameters are set in millimeters. The measuring current is set in mA.
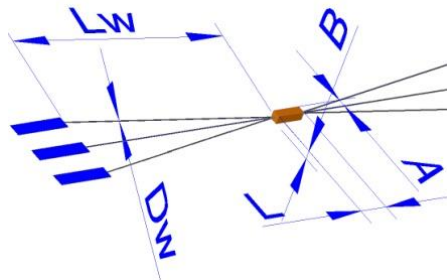

If necessary, the values of the parameters can be stored in base. For this purpose press the button «Add», set a name and press «Ок». For loading parameters, it is necessary to choose a name from the list of samples and to press the button «Load». If it is necessary to remove a sample from the base, choose a name of the sample from the list and press the button «Delete».

For confirmation of the given parameters for a chosen sample, press the button «Apply» or the button «Ok» if you do not want to continue editing of parameters of a sample.

For a choice of an edited sample, it is necessary to choose it from the drop-down combo box.

If not all the samples take part in measurements, it is necessary to specify what samples do. For this purpose, in the main menu "Edit-Samples" remove or establish ticks with appropriate numbers. Thus, it is possible to remove or put a tick in a field «Use this sample in measure».
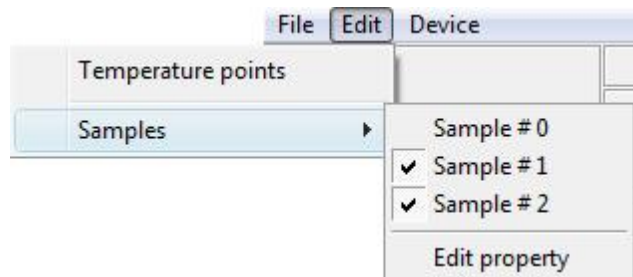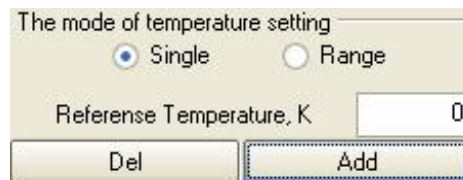
Important!!! Before the beginning of the measurement, it is necessary to set all the parameters of samples.

7.5. Temperature Points Setting

Before the beginning of the measuring process it is necessary to set temperature points.

There are two ways of doing it: specifying a certain point or a range with a given step. The mode can be chosen by means of a radio-box.

In the mode of measuring by points, a temperature point is set in Kelvin. In the mode of measuring in a temperature range, an initial and final temperature points as well as a step are set.

For adding a point (points), use the button «Add». If it is necessary to remove a temperature point, choose a undesirable point from the list of temperature points and press the button «Del».

7.6. Start and Stop of Measurements

Important!!! Before beginning to measure, be sure the LED «System Ready» is on and there is a message «Vacuum: Ok».

To start measuring, it is necessary to press the button «Start» on the control panel. The automatic procedure of measurements for a temperature given and a sample chosen will begin. The current temperature and a sample are highlighted in the list of temperature points.

If it is necessary to stop the process, press the button «Stop».

7.7. Results Storage and Loading

For the storage of the measured temperature points it is necessary to choose from the main menu «File-Save». Indicate a name of the file and press the button «OK».

For the storage of a file in the text form with tabulation choose from the main menu «File-Save As». The test file can be used for export of the data, for example into Excel.

It is possible to load a file. For this purpose, choose from the main menu «File-Load». Select a file and press «OK».

7.8. Results Display

For display of temperature dependences, go to the bookmark «Result».
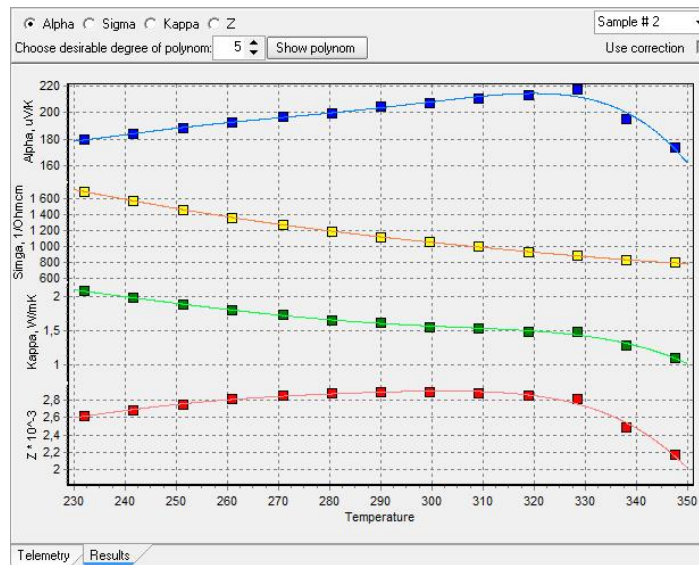
The measured temperature dependences (Alpha, Sigma, Kappa, Z) and corresponding polynomials are plotted on the diagram. By default the polynomial is of the fifth degree. The degree of a polynomial for each temperature dependence can be changed in the appropriate field. For viewing polynomial factors, press the button «Show polynom».

8. SECURITY MEASURES

- At operation, maintenance service and checking it is necessary to observe requirements of the Russian Standard «ГОСТ 12.3.019-80», «Service regulations of consumers' electronic devices» and «Rules of a labour safety at operation of consumers' electronic devices», or to apply similar documents of your country.

- The voltage on the contacts of the device at operation is up to 250 V, which is dangerous to human life. Any connections to the device and its maintenance service are only to be done at power switched off.

- During the operation of the vacuum station some of its parts are heated up. It is not allowed to touch metal parts of the vacuum station while operating and sometime after, sufficient for its cooling.

- Moisture on contacts and internal elements of the device are not allowed. The usage of the device in aggressive environments in the atmosphere of acids, alkalis, oils, etc. is forbidden.

- The connection, adjustment and servicing of the device should only be performed by the qualified experts who have studied this document.

9. MAINTENANCE SERVICE

Service of the operational device consists of the technical inspection.

At the maintenance service of the device observe the security measures - see section 8 SECURITY MEASURES.

Technical inspection of the device should be carried out not rarer than once in three months and includes the following operations:

- cleaning of the device housing of dust, dirt and extraneous subjects;

- cleaning of vacuum space of the vacuum table - wiping the vacuum table by ethyl alcohol;

- Cleaning of dust the edges of the fan by a vacuum cleaner;

- Cables checking;

- checking of reliability of inter-block connections.

The malfunctions found at the technical inspection should be removed immediately.

Checking of metrological characteristics of the device should be done not rarer than once in 3 years.

If necessary, make the adjustment of the device. It means the operations providing restoration of its metrological characteristics in case of their change during a long operation.

Important!!! Necessity of the adjustment is determined by results of the device checking only by the qualified experts of the metrological services carrying out this checking.

10. TROUBLESHOOTS

Possible malfunctions and ways of their elimination are given in the table below.

Appearance	Possible reason	Way of elimination
The program could not contact the control block	Faulty USB cable Necessary drivers are not installed	Malfunction reason elimination
Temperature value is not true	Breakage of a circuit of one of thermal resistances	Malfunction reason elimination
The red lamp "LEAKINESS" is at the control block of the vacuum system	There is a leak in the vacuum system	Leak elimination

Note. If a malfunction or a reason is not specified in the table, it is necessary to deliver the device for repair.