Instruments and Equipment

Long PVC tube (made of polyvinyl chloride)

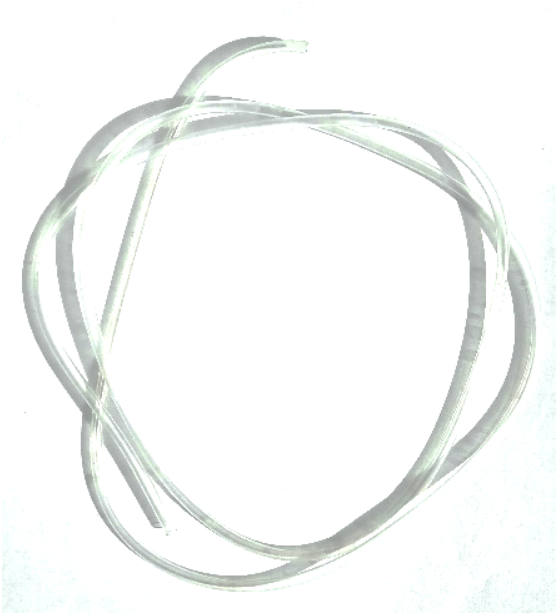

Fig. 1. A PVC-tube

Flasks and connecting tubes

A flask is the main vessel for measurements in this task.

Fig. 2. A flask

Plugs for flasks

A plug is made of silicone. The plug must be pressed firmly into the neck of the flask to ensure that the flask is securely sealed. Syringes with lock-pins are inserted into one of the plugs. A lock-pin is a needle that is designed to fit into the hole in the syringe piston. The second plug contains a thermometer inserted into it, which is used to measure the pressure-temperature dependence. Each of the plugs contains a nozzle that is designed to fit the connecting tube when connecting the flask with the manometer.

Press the ON button to switch on the thermometer. Select degrees Celsius as the unit of measurement using the °C/°F button. The thermometer has the shutdown function, which is initiated automatically after a short time. To continue measuring, simply turn the thermometer on again. The T_C temperature measured in degrees Celsius is converted to the T_K temperature measured in degrees Kelvin by the formula $T_K = T_C + 273.15$.

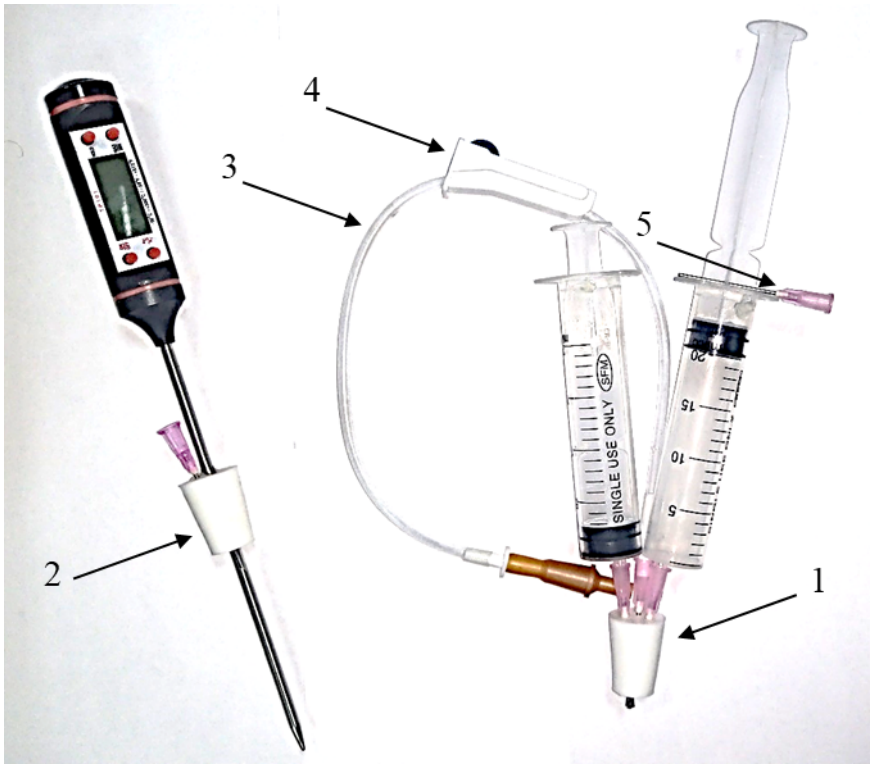

Fig. 3. Plugs for the flasks.
1 – a plug with syringes; 2 – a plug with thermometer; 3 – connecting tube; 4 – clip; 5 – lock-pin for the syringe piston.

Cold water box

Fig. 4. A box for cold water

Bottles with sparkling water

Use water from each bottle only once! If the amount of air in the bottle increases, then the water will become very degassed and unsuitable for the task.

Fig. 5. A bottle with sparkling water

Support stand

The support stand is used to fix flasks in a cold water box or in a water bath.

Medical syringes

Syringes of 20-ml volume and 5-ml volume are given out to students.

Fig. 6. Syringes

Electronic Scale (Weighing Device)

Fig. 7. Electronic scale
1 – weight reset button to "0"; 2 – on-off button;
3 – backlight button; 4 – button for switching to the body-counting mode (not used in this task);
5 – units of measurement button

Water bath

Fig. 8. Water bath
1 – temperature inside the bath at present time; 2 – preset temperature

The current temperature in the water bath is shown on its display. The second display shows the preset temperature, which the bath tends to maintain. **Never press buttons on the water bath!**

Metal cylinder with holes

The cylinder is installed in a water bath. A flask is immersed in the cylinder during pressure measurements at a temperature different from the room temperature. The cylinder is used to prevent water from spilling out during the shaking of a flask submerged in warm water.

Fig. 9. Metal cylinder with holes

Differential manometer

The differential manometer (an electronic device used here to measure the pressure difference) is the main measuring instrument in this task. The manometer measures the difference in pressure inside the flasks that are connected to its two inlets. During the experiment, the manometer is connected to the computer for more convenient study of measured quantities. The internal volume of the manometer inlet is approximately 0.5 ml (± 50 %).

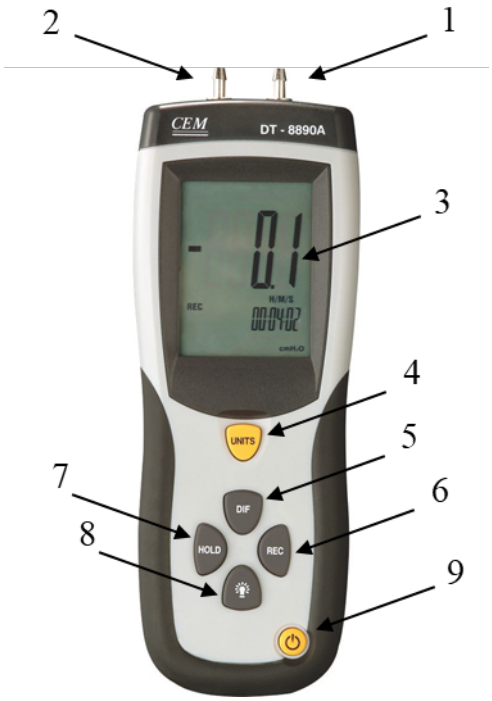

Fig. 10. Differential manometer
1 – positive input; 2 – negative input;
3 – display; 4 – units of measurement button;
5 – reset button; 6 – measurement record button;
7 – hold button to retain the reading; 8 – backlight button; 9 – on-off button.

Measuring tape

Fig. 11. Measuring tape

Sticky tape

Fig. 12. Sticky tape

Laptop and software

Manometer application is used to record and display the pressure, that is measured by two differential manometers (pressure gauges) DT-8890.

How to turn on the manometers (pressure gauges) and start the application

1. Connect both manometers to USB ports of the computer. Remember which USB port corresponds to which manometer. It is important to know in case measurements failure.

2. Turn on the manometers by pressing the corresponding buttons on their case.

3. Start the Manometer application. The application icon is on the computer's desktop.

Fig. 13. Manometer application icon on the desktop

WARNING! The application will NOT function correctly unless BOTH manometers are connected to the computer.

Application main screen.

Application main screen is shown in the Figure 14. It has two identical windows, each of them displaying the graph of current value of pressure. The screen has also an "Exit" button, that terminates the application.

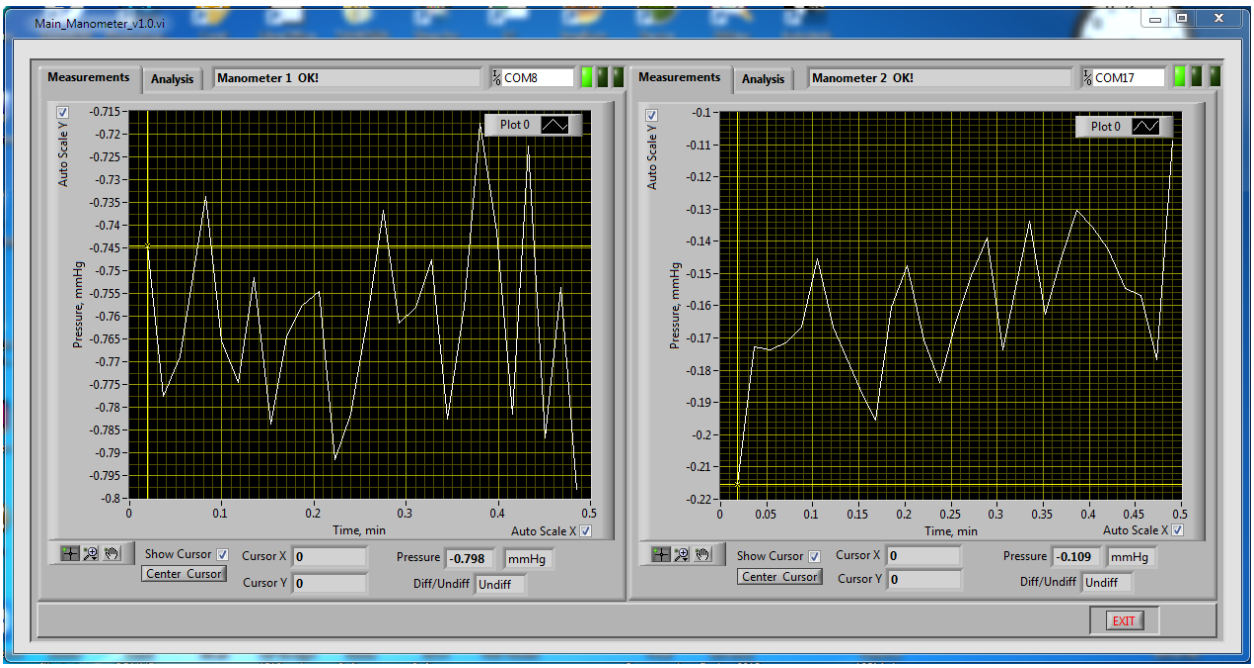

Fig. 14. Application main screen

A single window for the measurement of current value of pressure is shown in the Figure 15.

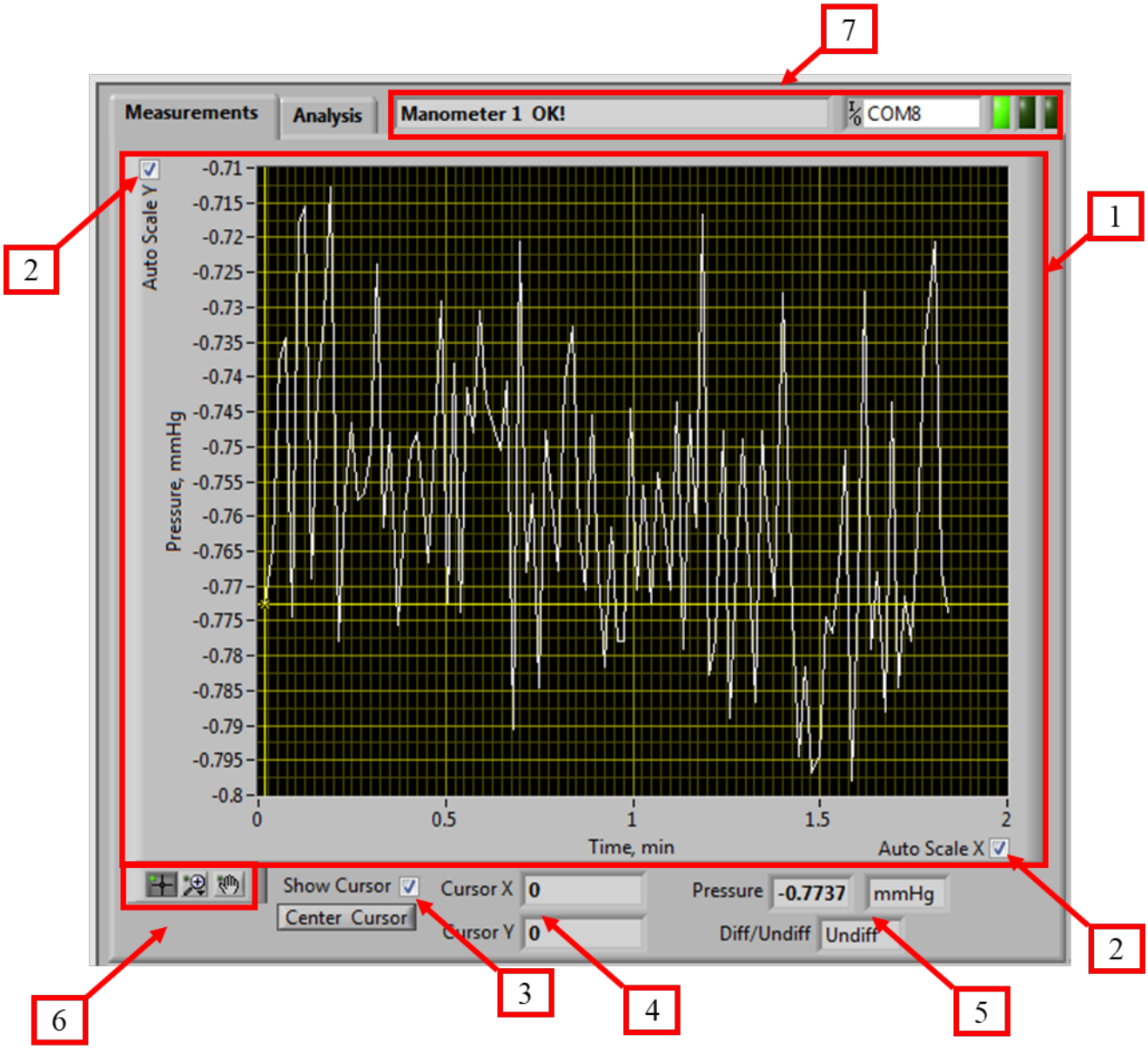

Figure 15. The window for the measurement of current value of pressure by first manometer. "Measurements" Tab.
1 – graphic representation of time-dependence (min) of the measured pressure (mmHg).
2 – turn on and off autoscaling for X (Auto Scale X) and Y (Auto Scale Y).
3 – turn on and off the cursor (Show Cursor) and show cursor button (Center Cursor) in case it is out of the displayed range.
4 – coordinates of the cursor current position (Cursor X, Cursor Y).
5 – Current value of the measured pressure (Pressure), units (mmHg) and the manometer operation mode (differential/non-differential, Diff/Undiff).
6 – tools for graph manipulation and analysis.
7 – error and service messages display bar.

Tools for graph manipulation and analysis.

The section (Figure 16) has three tools, that can be used to manipulate and analyze the graph in detail.

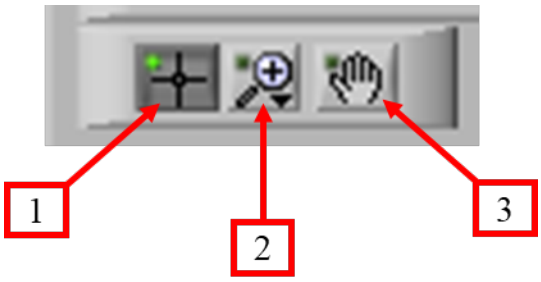

Fig. 16. Tools for graph manipulation and analysis
1 – Cursor, 2 – Magnifier, 3 – Move.

The Cursor tool allows you to accurately read from the screen the coordinates of the point that the cursor hovers over. In order to use this tool, you must click on this button. After that, the screen will be able to capture the cursor with the left mouse button and move it according to the graph displayed on the screen. If you do not see the cursor on the graph (for example, due to a change in the scale of the axes), click on the Center Cursor button. The cursor moves along the graph area by dragging a vertical or horizontal line or by dragging the intersection of these lines. The coordinate values of the point located at the intersection of lines can be seen in the coordinate output fields (Cursor X, Cursor Y).

The Magnifier tool is used to zoom in or out the area on the graph (Fig. 17). In order to use this tool, click on it with the mouse cursor, select the required mode, move the cursor to the graph area and select the necessary region on the graph.

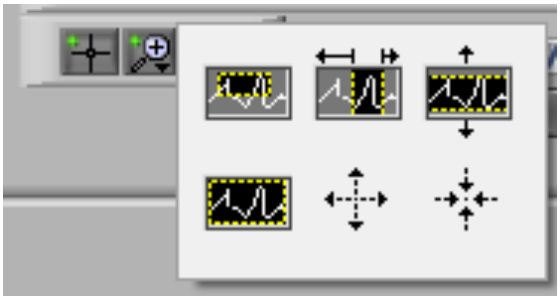

Рис. 17. Magnifier tool

The Move tool allows you to move around the graph area. This tool is especially useful if the graph is enlarged by the Magnifier tool.

Logbook.

When you start the application it automatically writes all measured results for both manometers to a log. If the application or computer failure occurs, all the measured data will be saved on the hard drive and can be restored and analyzed. When you restart the program, the data will be written to the next log file (a file with a different name).

The file name for data recording is generated automatically in the format "YearMonthDay_HoursMinutesSeconds_ManometerID _log.txt"

For example, a file with the name "20190829_125202_M1_log.txt" means that the beginning of measurements and writing to this file was made in year 2019, 8th month, 29th day at 12:52:02 for manometer number 1.

To open the data and analyze the graphs from a log file, go to the Analysis tab. This tab is shown in Fig. 18.

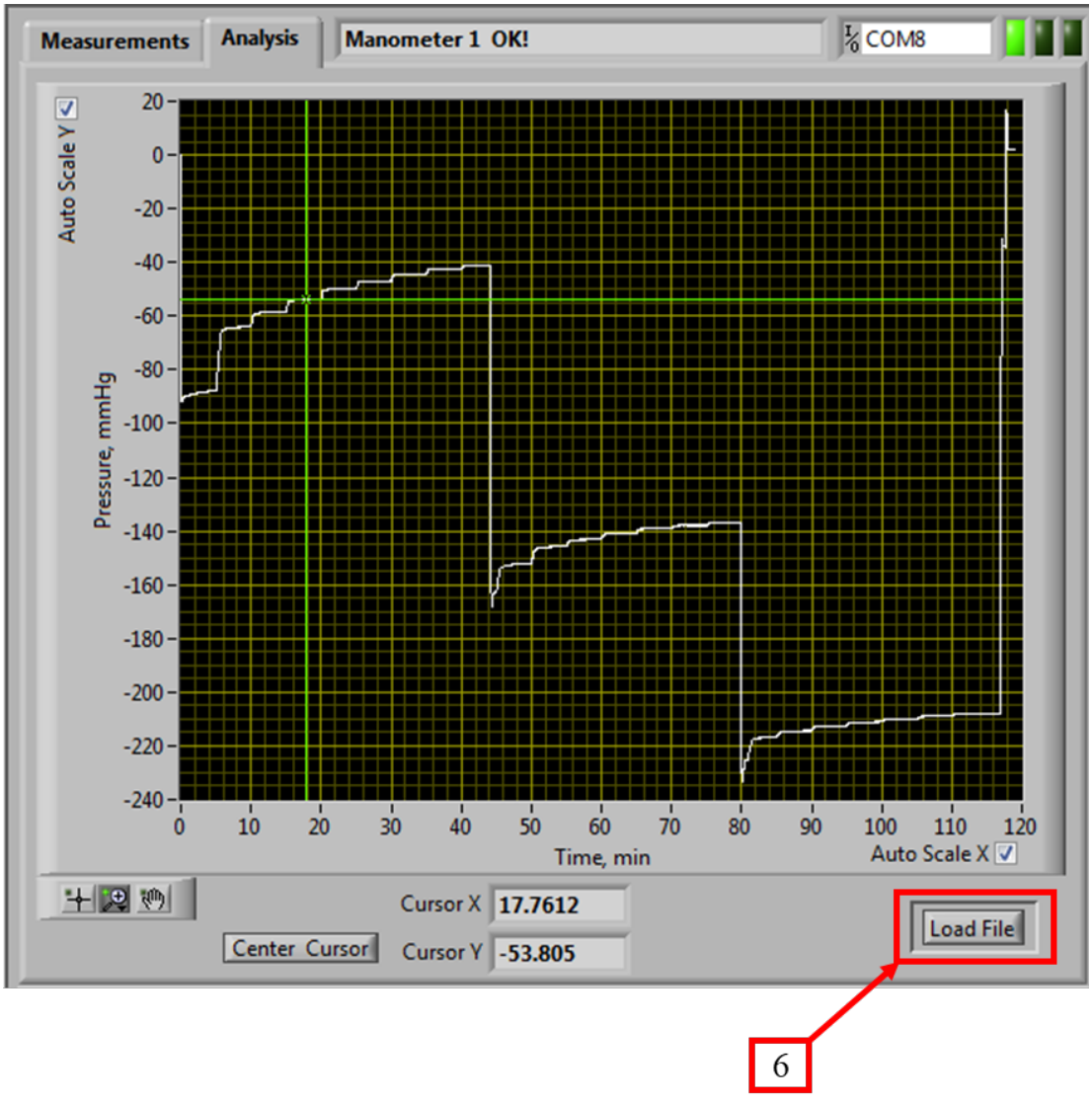

Fig. 18 The window for saved data analysis (Analysis tab)
1 – open saved data button.

To load the saved data, click the Load File button. In this case, the data saved in the selected file will be displayed on the graph.

The way to study the graph in detail and use the tools is the same as described previously.

When you switch to the Analysis tab, the program continues to measure and save the current pressure values to a file. You can do both, analyze the results and measure the pressure time-dependence.

Troubleshooting.

Normal operation.

If the program reads information from both manometers, and there are no errors, then in the error and service messages display bar the green indicator is on and "Manometer 1 OK!" (Or "Manometer 2 OK!") message is displayed, as shown in Fig. 19.

Fig. 19. Normal operation

If you accidentally pressed the Units button on the manometer and changed the pressure units, the application will automatically recalculate the pressure units to mmHg and continue measuring and recording data.

Manometer power off.

If the power of one of the manometers is accidentally turned off, a flashing message will appear in the error and service messages display bar with an indication to check the power supply of the corresponding manometer and the middle red indicator will be on, as shown in Fig. 20.

Fig. 20. Manometer power off display status.

In this case, turn on the power of the manometer, the application will continue to measure and write data to the log.

USB disconnection.

If the USB connection is lost and the application lost its communication with the manometer, a flashing message will appear in the error and service messages display bar indicating to check the USB connection and the two red indicators will be on, as shown in Fig. 21.

Fig. 21. USB disconnection display status.

In this case, carefully check the connection of the USB cable to the computer and, more importantly, to the manometer. You need to connect the USB cable to the same USB port to which the manometer was connected previously. When the connection is restored, the application will continue to measure and write data to the log.

In very rare cases, both manometers may disconnect. In this case, a flashing warning will appear in the error and service messages display bar of all windows that no manometers have been found, as shown in Fig. 22.

Fig. 22. No manometers found display status.

In this case, connect the first manometer, wait until the application starts reading data from it, and only then connect the second manometer. You need to connect the USB cables to the same USB ports to which each of the manometers was connected previously, and initially you need to connect the manometer that was previously connected first. If you change the order of connection, the manometers can be swapped, and it will be difficult for you to analyze the data on the graphs.

In unforeseen cases address the Olympiad Staff.