OOO NPP «STRUCTURAL DIAGNOSTICS»

Portable laser spectrometer
LIS-02

User Manual
LIS02.102023-RE

Yekaterinburg
2023

Abstract

This document is the user manual for the LIS-02 portable laser spectrometer.

The manual contains a description of the spectrometer, how it works, technical and metrological data and other information necessary for the operation of the spectrometer.

The Manufacturer reserves the right to make changes in the design of the device, its components and auxiliary software, this manual and other technical or service documentation that does not violate the stated metrological characteristics.

Contents

1. Basic product information and technical data

1.1. Purpose and application

Portable laser spectrometer LIS-02 (hereinafter referred to as Spectrometer) is designed to measure the mass fraction of chemical elements in metals and alloys. The spectrometer provides high speed in detecting chemical elements such as C, Si, Mn, Cr, Ni, Co, Fe, Mg, Al, V, Cu, Zn, Sn, Mo, Ti, W, Nb, Cd, Pb and others.
Included in the state register of measuring instruments under № 85726-22 (Russian Federation).
The method for determining the concentration of elements is similar to the method described in GOST R 54153-2010 and GOST 18895-97.
The spectrometer can be used in the following areas:

- Sorting of steels by grade;
- Sorting ferrous and non-ferrous scrap metal;
- Spectral analysis in laboratory tests;
- Styloscopy of basic and welding materials and finished products;
- Quality control of chemical composition in the production of products from metals and alloys.

1.2. Features

- **Accuracy.** The LIS-02 spectrometer provides high resolution over the entire measurement range, which provides sufficient accuracy to determine the chemical composition of samples.
- **Portability.** Small size and weight comparable to a manual power tool.
- **Reliability.** Lack of brittle elements compared to X-ray fluorescence (XRF) spectrometers. The metal nose element of the body allows working with sharp metal chips without fear for the safety of the device. Protection of optical elements with protective glass provides additional protection against mechanical damage of internal elements of the device.
- **Built-in grade library.** Based on the results of the analysis, a grade of steel or alloy corresponding to the percentage of chemical elements of the controlled sample can be displayed on the spectrometer screen. The spectrometer can be equipped with any grade library at the customer's request.
- **Security.** Laser safety class 3b.
- **Monolithic all-in-one housing** with a measuring start button (trigger) on the main handle.
- A 5-inch LCD touchscreen display is used **for data visualization** and control.
- The spectrometer is **powered** from a 220 V main supply via a power adapter with an output voltage of 19.5 V, or from four batteries of type 18650. Unprotected Li-Ion batteries with a nominal voltage of 3.7 V and a current output of at least 2 A can be used.
  Attention! Do not leave the spectrometer plugged in unattended (even if the device is turned off).

1.3. Requirements for the level of personnel

A specialist with basic computer skills can read and perform work with the spectrometer.

Attention! The spectrometer contains a laser source, class 3b. Do not point the outlet of the device at persons or animals. Staff should be informed of the dangers of laser exposure and measures to protect the eyes from IR laser radiation.

1.4. Main metrological and technical characteristics

The basic metrological characteristics of the spectrometer are given in *Table 1*.

Table 1. Metrological characteristics

Specification Name	Description
Spectral range, nm	177-370
Spectral resolution, nm, no more than *	0.5
Sensitivity, (heard)/(%), not less than**	8 000
Permissible relative SD output signal limits, %**	10
Instability of the spectrometer output signal in 6 hours, %**	10
* the value is normalized for Ni at a wavelength of 221.65 nm with a mass fraction of Ni not exceeding 15%. ** values are normalized for C (193.09 nm), Cr (313.20 nm), Mn (279.48 nm), Si (288.16 nm), Ni (221.65 nm) with a mass fraction of these elements not exceeding 15%.	

Verification of the spectrometer is carried out according to the document MP 74-251-2021 "GSI. portable laser spectrometers LIS-02. Verification procedure", approved by UNIIM - branch of FGUP "VNIIM named after D.I.Mendeleyev" 22.03.2022.

The interval between verifications is 1 year.

Description of the verification in Section 5.10.

The main technical characteristics of the spectrometer are given in *Table 2*.

Table 2. Technical data

Specification Name	Description
Source of excitation of the spectrum	solid state laser
The wavelength of the excitation source, nm	1064
Radiation safety class according to GOST R 50723-94	3b
Process pause time to eliminate condensation on the surface of optical elements, not less than one hour	2
Time to exit from "off" mode, max	60
Time to exit from standby mode, max	3
Minimum measurement time, sec	1
Measuring results display tool	5 inch LCD display
Data transfer interfaces	WiFi, Bluetooth
Type of internal power supply	4 lithium batteries 18650
Type of external power supply	DC voltage source
Electrical power supply parameters from the AC adapter: AC voltage, V AC frequency, Hz from the battery: DC voltage, V	 200 to 240 50 11 to 17.2
Maximum power consumption, W	25
Case material	plastics
The degree of protection against external influences, not worse	IP52
Overall dimensions (height×width×depth), cm, max: spectrometer of the shipping case	 35.5×13.5×32 62×42×36
Mass, kg, no more: spectrometer transport case with the spectrometer	 2.2 11
Operating conditions: ambient air temperature, °C relative humidity, %	 minus 10 to plus 40 20 to 98
Average operating time per failure, hours, not less	10000
Recommended service life, years	5

1.5. Design execution

Structurally, the spectrometer is made in a plastic shockproof case. The appearance of the spectrometer with the location of connectors, indications and controls is shown in Figure 1. There is a hole in the front of the housing for measuring channel 1 with a metal shutter. There is a label 2 on the bottom with the serial number and date of manufacture. There is a measurement start button on the main handle 3. The LCD display 4 is positioned at a convenient angle to monitor the progress of the measurement. Battery pack 5 for four 18650 type external batteries is located at the bottom of the case. The power on/off button with status indicator 6 is located on the bottom of the spectrometer on the LCD side, next to it is the connector for external power supply 7. The safety bracelet 8 is designed to prevent the spectrometer from falling during operation, so it is recommended to put it on the hand.

Figure 1

1. *Measuring channel hole*
2. *Label with the serial number and date of manufacture*
3. *Measurement start button (trigger)*
4. *LCD display*
5. *Battery pack*
6. *Power on/off button with status indicator*
7. *External power supply connector*
8. *Safety bracelet*

1.6. Complete kit

The spectrometer is supplied in the kit:

Name	Designation	Quantity
Portable laser spectrometer	LIS-02	1 pc.
Power adapter	-	1 pc.
Shipping case	-	1 pc.
Batteries	-	8 pcs.
Charging device	-	1 pc.
Reference sample	-	1 pc.
Spare safety glass	-	1 pc.
Thermal printer	-	1 pc.
Thermal tape (width 57 mm)	-	1 pc.
Safety bracelet	-	1 pc.
Passport	-	One copy.

2. Preparing the spectrometer for operation

Before using the spectrometer, it is necessary to check for mechanical damage, oxidation, rust or dirt on the case and connectors of the spectrometer. If contamination is present, it should be removed with a damp cloth or a soft rag.

Attention! Do not use chemically active liquids (spirit, acetone, solvent, detergents, etc.) to remove contamination.

Attention! Do not use the device if it is mechanically damaged or shows signs of corrosion.

Attention! Do not measure on flammable and explosive materials, liquids and their vapors.

When using replaceable batteries as a power supply, they should be charged and installed in the battery pack of the device before starting the device. Measurements with the red battery charge indication (in the upper left corner) will result in underestimated measured concentrations.

Attention! The batteries are not charged by connecting the spectrometer to the mains power supply.

Attention! Batteries must not be operated without safety covers or if the external casing of the battery is damaged.

Condensation can form on the surface of the optical elements when the climatic conditions change, for example when the device is moved from a zone with cold air to a zone with warm air. Do not operate the device if condensation is forming on the components and surfaces of the device.

If the device has been in a cold room or outdoors for a long time, it is necessary to maintain a **technological pause of at least 2 hours** before starting operation.

Do not work with an unprotected device in the rain.

Press and hold the power button of the device. When the software has finished loading, the program's start window will appear on the screen.

If the batteries have been discharged, the operation of the instrument will be stopped. To continue using the device, remove the discharged batteries from the battery pack and install a set of charged batteries in the battery pack.

Attention! Batteries from different manufacturers, different capacities and models, and batteries with different charge levels must not be used in the same set.

Attention! In the event of signs of smoke or ignition, immediately stop using the device and take measures to prevent the occurrence of fire or a dangerous situation.

After starting the spectrometer, carry out a test measurement using the reference sample (RS) supplied with the device.

The chemical composition of RS can be seen in Appendix 6 - this is a standard sample of UG35b (УГ35б).

Place the RS on the measuring channel hole of the spectrometer. Press and release the trigger (Figure 1) to start the measure. During the measurement, make sure that the RS is in close contact with the spout of the spectrometer. After the end of the measurement process, check that the chemical composition of the device corresponds to the readings on the LCD display.

To prevent battery failure, do not store the spectrometer for an extended period of time with batteries installed and do not store fully charged batteries. Batteries must be discharged to 60-75% for long-term storage.

Attention! To operate the device from the 220 V mains, use the AC adapter labeled «Connect only to the spectrometer». This power supply must not be used to connect the Charging device.

Attention! The duration of measurement of samples that have a surface temperature between 50 and 100 °C should be no more than one minute. Do not perform measurements at temperatures above 100°C !

The spectrometer is an electron-optical device. The optical components of the spectrometer are subject to factors such as contamination of optical surfaces or the resulting condensation.

The contamination of the optical surfaces inside the device body is a long process and leads to a gradual long-term deterioration of the metrological characteristics of the device.

Condensation of moisture in the surrounding air causes the device to stop temporarily when performing its intended function for a short period.

Condensation (in the form of frost or dew) formed on the cold surface of the material if the ambient temperature and humidity exceed a certain threshold. For example, if a cold object with a relative humidity of 80% is brought into a warm room with a temperature 3.5°C lower than the room temperature, condensation will form on the surface of the object. For reference information on the criteria of condensate formation, it is possible to use the calculation formula or tabular method presented in ISO8502-4 standard.

Therefore, we recommend in order to exclude the influence of condensate on the spectrometer performance, it is recommended to keep the technological pause:

if the device is kept in the cold for a long time (e.g. during transportation), it must be brought into a warm room and kept in a technological pause (at least 2 hours) before switching on. The duration of the technological pause depends on the temperature and humidity of the room. The higher the humidity and the lower the temperature, the longer should be the technological pause.

3. Sample preparation

When using the laser spectrometer LIS-02, a very small area is analyzed - a point not more than 0.1 mm in size; micrograms of the substance are vaporized during burning. Thus, the more homogeneous in volume the analyzed sample is, the more accurate will be the result of the chemical composition obtained by one or more points.

The result of the analysis will depend on the condition of the surface and the structure of the entire sample, so it is important to remove dirt from the surface, traces of corrosion and make it sufficiently even, as the presence of cracks, pits and other defects can lead to erroneous results. For surface preparation, an emery wheel or sanding with a rotating disc of sandpaper will do the trick. The speed of rotation can affect the structure of the material, so low speeds are recommended.

The measurement results obtained must be analyzed in terms of the material being measured and its chemical properties. For example, when obtaining cast iron alloys, attention is paid to the hardening to obtain white cast iron in which the carbon is in the cementite state. In this state, the carbon concentration can be determined by emission spectrometers and the composition is quite homogeneous. But more often the composition of cast iron contains carbon in a free state in the form of graphite and is located at the grain boundaries, which makes it difficult to quantify the carbon composition. Detailed information on sampling cast iron in GOST 7565-81.

Another example is titanium in stainless steels. Titanium, being a light element, may have a scatter of content at different points.

4. Description of the purpose of the firmware, its structure and functions

4.1. User interface

4.1.1. The spectrometer firmware is integrated and stored in the non-volatile memory of the device. The device does not have wired or wireless communication interfaces to access the device memory and firmware settings. All measurements are also stored in non-volatile memory.

4.1.2. Attention! The firmware is constantly being improved and the firmware interface of a particular device may differ from that described in the user manual in terms of button layout, sequence of operations and data display.

4.1.3. After switching on and loading the spectrometer firmware, the main window appears (Figure 2).

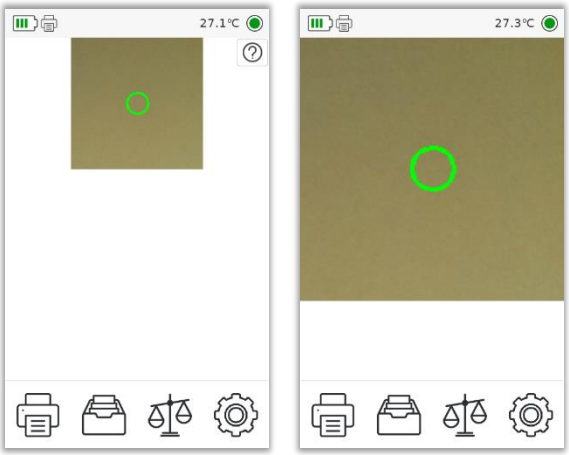


Figure 2 Main window of spectrometer firmware

4.1.4. The following information is displayed in the upper part of the LCD display:

- the battery charge level,
- the printer icon shows the connection of the device to the printer network,
- the current temperature value in degrees Celsius inside the spectrometer,
- the circle, which should be colored green if the device works correctly.

4.1.5. The device power supply indication can be displayed in two ways: battery operation with battery charge level display and mains power supply indication.

Attention! The batteries are charged using the charger supplied that came with the device.

	battery icon showing the charge level of the batteries on which the device works
	the empty battery icon with power cord plug - the AC power adapter is connected, the spectrometer is powered by AC mains.

4.1.6. To enlarge the image received from the device video camera, click on this image. Clicking again will reduce the image to its original size.

4.1.7. Press the menu items on the touch screen to operate the firmware.

4.1.8. At the bottom of the display there are buttons to control the spectrometer operation modes:

	button to print the current measurement result to the wireless thermal printer supplied with the spectrometer
	button to view the history of all measurements taken on the spectrometer, see chapter 4.4
	button to start the Comparison mode, see chapter 4.5
	spectrometer settings button, see chapter 4.6 for details

4.1.9. If you have a question during the measurement process, you can send measurement spectra with text explanations via the Internet (Wi-Fi). Click this button with a question mark. To view the order in which the data was sent, click on the " Information about sending" button. Write the information: your phone number and a text message explaining the problem (Figure 3). Click the "Send" button. After the data has been successfully uploaded, a window will appear with the message "Upload completed".

	technical support button

By default, the "Last" button is highlighted, which allows you to send spectra of the last measurement. When you select "For the period", you will be selected the date. All spectra taken on that day will be added to the support message.
To cancel the sending, click the "Cancel" button.

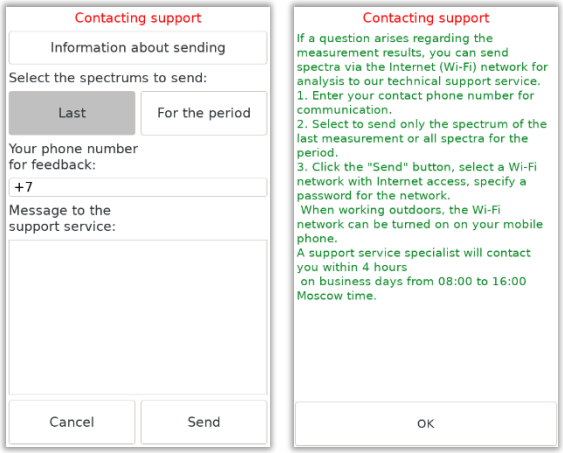


Figure 3 Support window

4.2. Methodology of measurements

4.2.1. Before performing measurements, make sure that the protective glass is free of dirt, if necessary, wipe it with a dry cotton swab (see Appendix 3). Prepare the sample surface for measurement (item 3). Place the sample to the measurement channel opening located on the spectrometer spout (Figure 1) and press measurement start button (trigger) on the device handle to perform the measurement.

4.2.2. Measurements can be performed in two modes: express analysis by single measurement and analysis in serial mode.

4.2.3. Express analysis is started by a single press of the trigger. This measurement method is for quick assessment of the chemical composition of the sample and determination of the alloy grade.

4.2.4. The analysis in the batch mode is started by holding the trigger for two seconds (see 4.2.13). The mode is used for more accurate quantitative chemical analysis in comparison with express analysis.

4.2.5. The measurement point is on the order of 0.1 mm, so for complex alloys, a single measurement at different points may result in significantly different results.

4.2.6. The user shall control the location of the sample to be measured relative to the inlet of the device using the built-in high-resolution video camera. When making measurements, it is necessary to move the device relative to the sample so that measurements are made at a new point each time.

4.2.7. Attention! To ensure the reliability of the measurement results, special attention should be paid to the quality of adhesion of the device inlet to the sample to be measured.

4.2.8. The device uses different parameters for measuring ferrous and non-ferrous alloys. If the sample needs to be measured with parameters of a different base, it will be necessary to repeat the measurement when using single mode. In batch mode, the parameters are changed automatically.

4.2.9. At the end of each measurement, a table of the main chemical elements of the sample with their percentage of content shall be displayed.

4.2.10. At the end of measurement the grades of steel or alloy suitable for the controlled sample according to the selected grade library (see 4.9.2) are displayed. If at least two grades from the selected grade library fully match the measured values, the result will be shown in the form of three columns with several grades at once.

	Button to view the next matching grade
	Button to view the previous variant of the grade
	Button to select another grade from any grade library to compare with the measurement result. The button appears after scrolling through the appropriate grades or immediately if no such grades have been found.
	Button to enter a description for this measurement

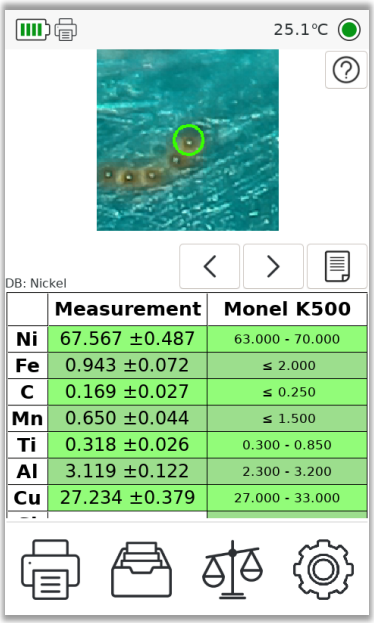


Figure 4 Measurement results of Monel

4.2.11. Attention! The result is the determination of the chemical composition of the metal and the automatic reference selection of grades. The same chemical composition can be matched by several grades.

4.2.12. The spectrometer comes with pre-installed grades library: GOST, AISI/ASTM, DIN, BS, JIS, UNS. The grade library GOST contains more than 3000 Russian grades. If necessary, the user has the possibility to add grades of alloys in the grade library, in more detail in 4.9.

4.2.13. The batch mode will return an elemental composition of the alloy as analyzed by several burns with determination of standard deviation (SD), see 4.3. The batch mode allows for a more reliable result in comparison with express-assessment.

4.2.14. The batch mode is started by holding down the trigger for two seconds. The device starts to automatically perform sequential measurements. After each measurement, it is necessary to move the sample under study so that the next measurement is in a new area. The results of all measurements are automatically averaged, the average values in the form of percentage of chemical elements in the controlled sample and SD are displayed on the screen.

4.2.15. The concentration of the element of interest is determined by the intensity of individual spectral lines, called analytical lines. The dependence of the intensity of analytical lines on the concentration of elements in the sample is linear. The wavelengths of spectral lines, the choice of standard samples and the order of calibration dependencies are determined by the method of measurements for a particular object and stored in the appropriate database in the non-volatile memory of the device.

4.2.16. We recommend using the Positioning function to measure samples with an uneven surface or irregular shape (see section 4.6.1.7.4).

4.2.17. The exclamation mark (!) indicates that the spectral line intensity is too high (Figure 5).

If there is such an error, it is necessary:

- wipe the safety glass;
- make sure the sample fits well;
- re-measure.

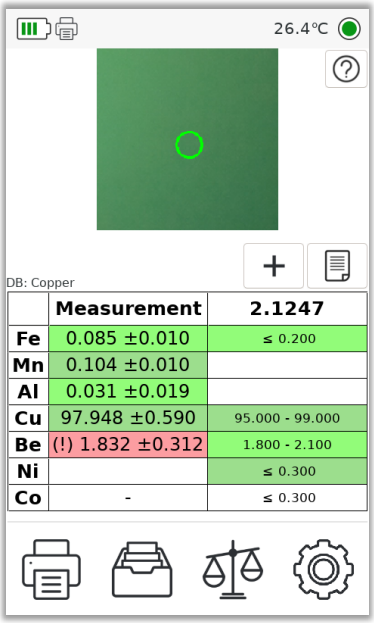


Figure 5 Beryllium measurement error in copper

4.3. Quality control of element concentration measurement

During a batch mode the device analyzes the quality of each measurement, incorrect measurements are discarded. If the percentage of incorrect measurements exceeds 50%, the table cell is colored red. For reliable measurements, their SD from the average value is analyzed (equation 1).

$$D = \frac{S_0}{\bar{x}} \cdot 100\% \quad (1)$$

D – Ratio of SD to average of valid measurements,

S_0 – standard deviation,

$\bar{x}$ – arithmetic average of valid measurements.

For numerical evaluation of measurement quality the table shows SD is calculated according to equation 2 (GOST R 8.736-2011).

$$S_0 = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2} \quad (2)$$

S_0 - standard deviation,

n – number of reliable measurements,

x_i – *i* measurement,

$\bar{x}$ – arithmetic mean of reliable measurements.

Depending on the *D* value obtained, the cell with the measured value will also be color indication (Table 3).

Table 3. Matching the cell color to the value range D

Concentration range of an element	D value at green indication	D value at yellow indication	D value at red indication
0.0 – 0.1	< 70	70 – 250	> 250
0.1 – 0.2	< 30	30 – 70	> 70
0.2 – 0.5	< 30	30 – 45	> 45
0.5 – 2.0	< 20	20 – 35	> 35
2 – 10	< 10	10 – 25	> 25
10 – 100	< 10	10 – 15	> 15

4.4. View history

4.4.1. The History mode is used to view measurements on both the current and other days.

4.4.2. The name of the group, in which the viewed measurement is stored (see 4.6.1.8), the part label (see 4.6.1.9), description (see 4.2.10), date and time of the measurement are displayed at the top.

4.4.3. Each group shows the total number of measurements and the number of the currently viewed.

4.4.4. In the history there is a possibility to send spectra of a particular measurement through the button for contacting the technical support (see 4.1.9) in case of questions on the obtained result.

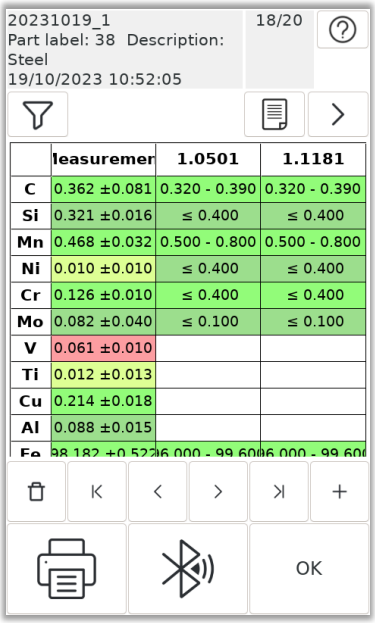


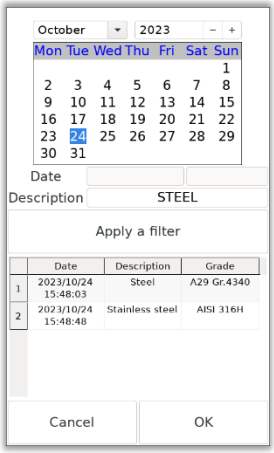
Figure 6 History window

4.4.5. Buttons for working with the measurement result:

	Button for applying a filter to history measurements (see 4.4.6)
	Button for selecting another grade from any grade library to compare with the result obtained (see 4.2.10)
	Button for entering a description for this measurement
	Button to clear in the input line (e.g. when entering a description)

4.4.6. Filter is used to search for measurements for a certain period of time (one or several days), as well as to search for measurements with a specified description. Specify the beginning and end of the period to filter, enter the description to which the measurement should correspond, then click the "Apply filter" button. The table will display the measurements filtered by date and description. To view the filtered measurements in the history, click the "OK" button or select the desired row. To cancel the filter application and return to the full history, press the "Cancel" button. If the filter is applied in the history, the button with the filter image will be highlighted in gray (Figure 7) and the selected dates will be displayed next to it. To reset the filter and return to the full history, press the filter button again.

4.4.7. If the filter is applied, it is possible to send via Bluetooth (4.4.11) a report in CSV format (**Ошибка! Источник ссылки не найден.**) with selected measurements.



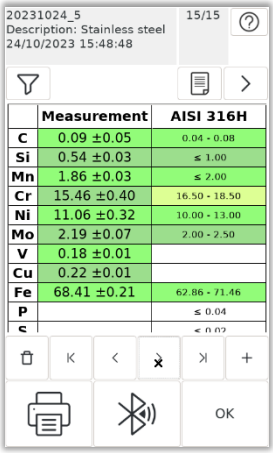


Figure 7 Application of the filter in the history

4.4.8. The history window shows information about the measurement: composition, SD (if a batch mode was used), a suitable grade from the selected grade library and the possibility to choose another grade for comparison and change of grade library (4.2.10), information about comparison (if this measurement was made in the Comparison mode, see chapter 4.5).

4.4.9. Buttons for working with measurements in the history:

	Button to delete this measurement
	Move to the previous measurement group
	Move to the previous measurement
	Move to the next measurement (only possible if the displayed measurement is not the last one)
	Move to the next group (only possible if the group is not the last one)
	Button to add this measurement to averaging

4.4.10. With the "plus" button, it is possible to average several measurements from the history, not necessarily single measurements.

4.4.10.1. Click the button to add the measurement to the averaging. The number of selected measurements will appear in place of the plus sign  , and a minus sign will appear near to it (you can see which measurements have already been added to the averaging).

4.4.10.2. Click the button , the previously selected measurement is excluded from the averaging.

4.4.10.3. After adding the necessary measurements to the averaging, you should click the button with the image of the selected number of measurements.

4.4.10.4. The calculated average value appears on the screen.

4.4.10.5. The result can be saved by click the button  . The saved result will be displayed as a separate measurement. You can add a comment to the averaged result using the button of description input (4.4.5).

4.4.11. Menu buttons at the bottom:

	Printing this measurement (the printer must be switched on, the printer connection icon must be on the device near to the battery charge indicator)
	Transmitting the measurement result via Bluetooth
	Button to return to the main spectrometer window

4.4.12. After pressing the button with the Bluetooth icon, the window of report format selection will appear. If the report is selected in CSV format, it is possible to select the range of data sending (Figure 8). After clicking the "OK" button, a window will appear to select the device to which the report should be sent. Select the desired line and click "Send". If your device is not in the list of available devices, try positioning it closer to the spectrometer and use the button to search for devices again.
If you have selected the "Filter" button, but the filter has not been applied in the history (see 4.4.6), the report will be generated empty. To cancel the sending, click "Cancel".

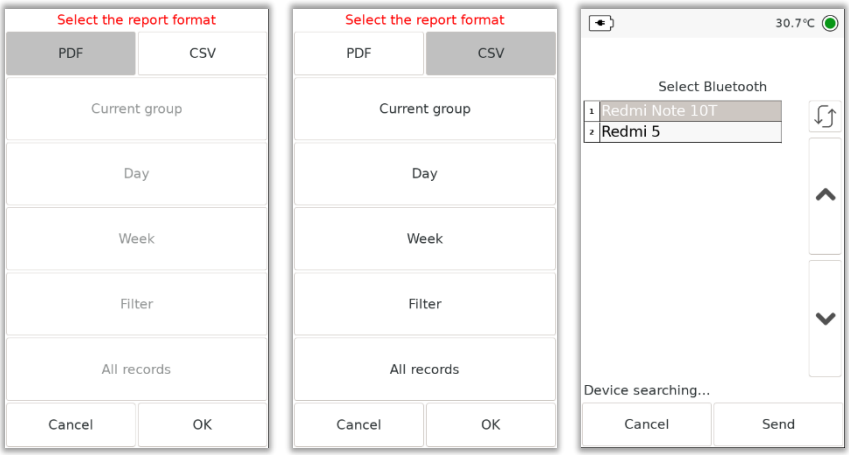


Figure 8 Sending a report via Bluetooth

	Button to re-search for available devices

When using a computer or laptop as a device to receive reports via Bluetooth, make sure that the connection of the devices is allowed and that the "Receive File" menu item on your personal computer is selected before sending.

4.5. Comparison Mode

4.5.1. The Comparison mode is designed to perform sorting of tested samples.

4.5.2. Three types of comparison are supported:

- Comparison with the available sample,
- Comparison for the composition of the etalon sample,
- Comparison for the grade.

4.5.3. Select the database that corresponds to the measurements in the settings (for more details, see 4.6.1.11) and switch on the comparison mode by click the scale icon.

	Button for switching to comparison mode

4.5.4. When Comparison mode is enabled, a dialog box will be displayed to select the type of comparison. The choice is made by clicking the corresponding button: Measurement (see 4.5.5), Etalons (see 4.5.6) or Grades (see 4.5.7).

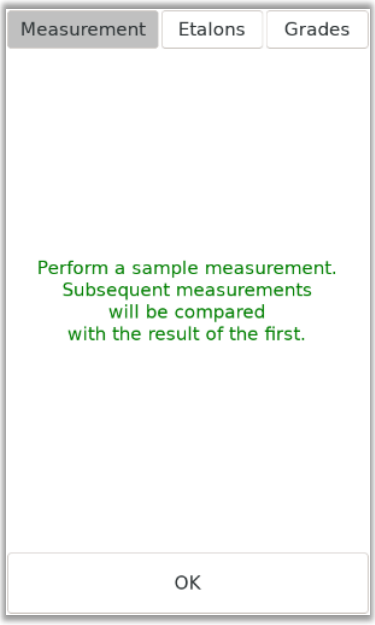


Figure 9 Selecting the type of comparison

4.5.5. Comparison with sample measurement.

4.5.5.1. The absolute accuracy of the spectrometer readings depends on the ambient temperature, especially the effect that can be seen in a portable device that should work over a wide temperature range.

4.5.5.2. The comparison with measurement is used to exclude the influence of external factors and to perform with high accuracy the procedure of sorting the samples in comparison with the test sample with known in advance content and concentration of chemical elements.

4.5.5.3. After pressing the OK button, perform measurement of the sample, which will serve as Etalon, in the batch mode. When performing measurements of the samples under study, the " Etalon" column will display the percentage of measurement deviation from the etalon, on the basis of which it is possible to make a conclusion about the conformity of composition.

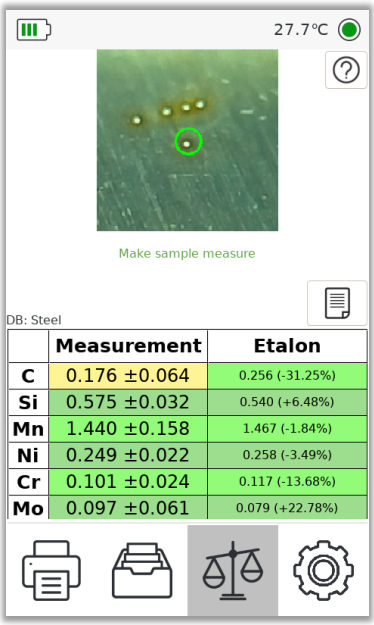


Figure 10 Measurement window in comparison with the etalon sample

4.5.5.4. In this mode, the right side of the table of concentrations of chemical elements displays the numbers corresponding to the concentrations for the control measurement, and the left side of the actually measured values of the etalon samples.

4.5.5.5. For ease of decision-making, concentration values in the field of the etalon are highlighted in color (*Table 4*).

Table 4. Correspondence of the color indication to the deviation of the measured concentration from the Etalon one.

Concentration range of an element in an available sample	Green	Yellow	Red
0.0 – 0.1	deviation of less 90%	deviation in the range of 90-99%	deviation of over 99%
0.1 – 0.2	deviation of less 50%	deviation in the range of 50-58%	deviation of over 58%
0.2 – 0.5	deviation of less 40%	deviation in the range of 40-46%	deviation of over 46%
0.5 – 2.0	deviation of less 20%	deviation in the range of 20-23%	deviation of over 23%
2 – 100	deviation of less 10%	deviation in the range of 10-12%	deviation of over 12%

4.5.5.6. Click the scale icon again to exit the comparison mode.

4.5.6. Comparison with etalon sample.

4.5.6.1. Select the Etalons. Etalons are stored in the device memory in advance (see section 4.11 "Etalons").

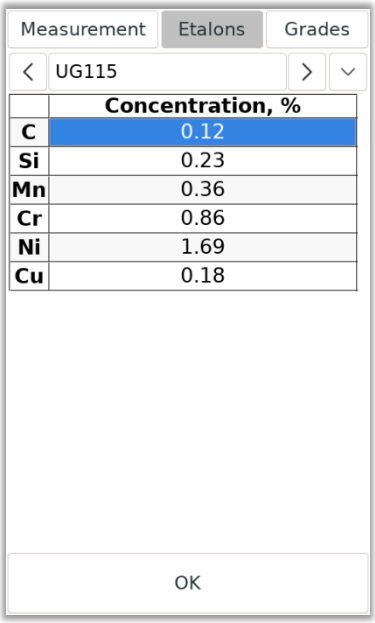


Figure 11 Etalon selection window

4.5.6.2. Select the etalon among the saved ones with the help of the left/right buttons at the top of the screen or with the help of the list of etalons for the selected base (see 4.6.1.11), which appears when you press the drop-down button.

	The drop-down button for viewing the list of grades

4.5.6.3. After clicking the OK button, the device enters the measurement mode.

4.5.6.4. In this mode, the right-hand side of the chemical element concentration table shows the element concentrations of the selected etalon is displayed, and the left-hand side shows the measured values of the sample.

4.5.6.5. For ease of visualization, the concentration values in the column of the selected etalon are highlighted in color (Table 3).

4.5.7. Comparison with grade.

4.5.7.1. Select the Grades. In this mode select the grade from the grade library for comparison (Figure 12).

4.5.7.2. The grade is selected using the drop-down list of grades, which appears when you click the drop-down button.

	the drop-down button for viewing the list of grades

4.5.7.3. The name of the grade library is shown above the list of grades. You can change the grade library by clicking the right/left arrows. Editing of the grade library see 4.9.

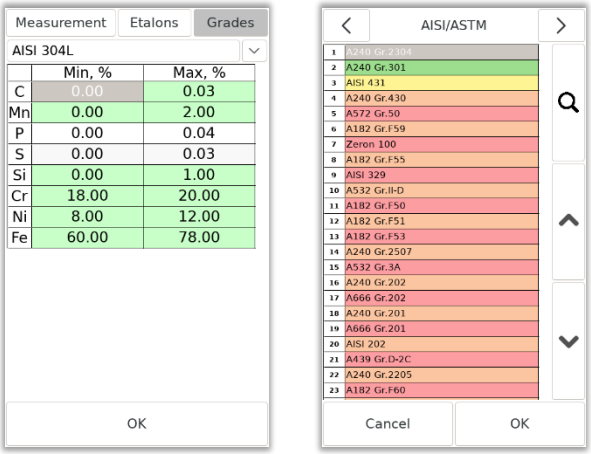


Figure 12 Grade selection window for comparison

4.5.7.4. Use the magnifying glass button to quickly find a grade in the selected grade library.

	Brand search button by name

4.5.7.5. After clicking the OK button, the device enters the measurement mode.

4.5.7.6. In this mode, the right side of the table shows the grade composition, the left side shows the measured values (Figure 13).

4.5.7.7. It's possible to select another grade for comparison in the measurement window using the plus button (see 4.2.10 for a detailed description).

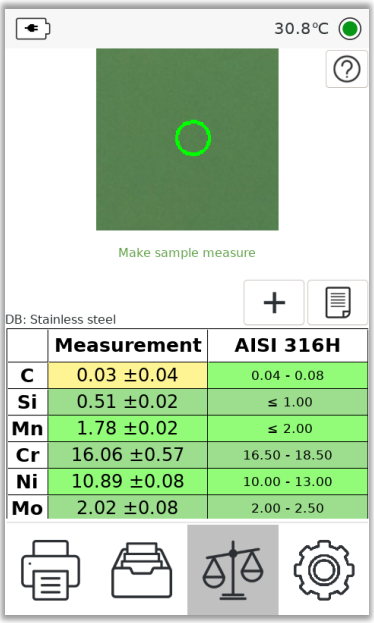


Figure 13 Measurement window with Comparison for the grade

4.5.7.8. For ease of visualization (how close the measured sample is to the grade), the concentration values in the column of the selected grade are highlighted in color (Table 5).

Table 5. Correspondence of the color to the deviation of the measured concentration from the concentration range of the element in the grade.

Mode	Green	Yellow	Red
The basic mode	Falls within the range of the grade	deviation of less 20%	deviation of over 20%
The batch mode	Falls within the range of the grade (with SD)	deviation of less 20%	deviation of over 20%

Attention! The color indication of the measurement result of the sample without using the comparison mode is like that described in Table 5.

4.6. Settings

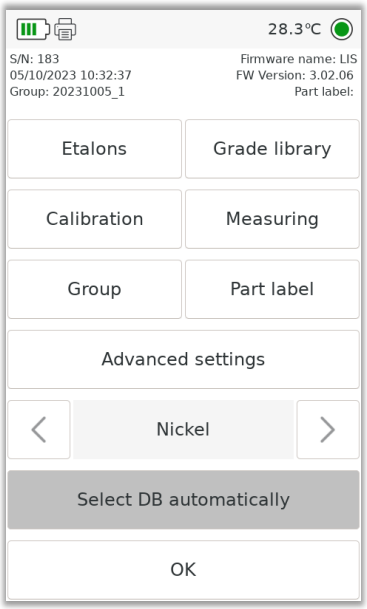


Figure 14 Spectrometer setting window

4.6.1. The spectrometer setting window contains the following interface elements:

4.6.1.1. The device serial number, current date and time (to change the date and time see 4.7.5).

4.6.1.2. Firmware name and version.

4.6.1.3. Current group names (see 4.6.1.8) and part label (see 4.6.1.9).

4.6.1.4. The "Etalons" button is intended for editing the list of etalons and specifying their composition. The etalons are used in the Comparison (see 4.5) and Calibration modes (see 4.8).

4.6.1.5. The "Grade library" button is intended for choose the necessary set of grades if more than one of them is set up or start the Grade library Editor (see 4.9) to change the composition of the grade or add a new one.

4.6.1.6. The "Calibration" button is intended for recalibration (graduation) of spectrometer readings on two or more samples with known chemical composition, for more details, see section 4.8.

4.6.1.7. "Measuring" - opens the additional menu of measurement settings. The measuring settings window has the following elements:

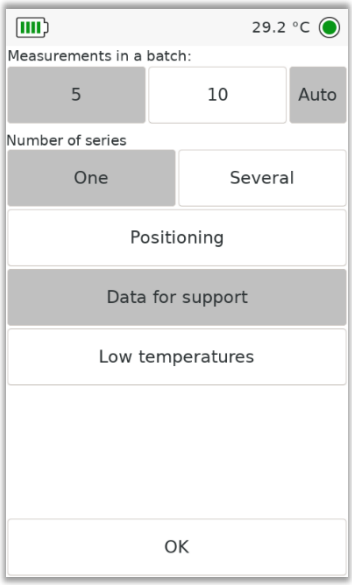


Figure 15 Measurement parameter settings window

4.6.1.7.1. The buttons for the number of measurements in a batch (5 or 10).

4.6.1.7.2. When the button "Auto" is pressed, automatic shooting of the series takes place: the device performs burns by itself at short intervals of time (you only need to move the device relative to the surface of the sample). If the "Auto" button is not pressed, when you switch to the batch mode, each burn in the series is performed by pressing the measurement start button, as in the single measurement. In this case the consecutive measurements will be joined into a series and the average value will be calculated.

4.6.1.7.3. Averaging switch for several measurement series. When the button "One" is clicked, one result of the current measurement is displayed with the SD. If the button "Several" is pressed, the measurement sequence of the series and their average value will be displayed (see Figure 16). Each individual measurement and the average result are saved in the history. If the button to start measurements is pressed briefly, the device will display the average of the measured values, the SD and the grade (here you can also select the grade from other Grades Library, see 4.2.10). Such averaging of results can be done

again with separately removed measurement series (when the button "One" is pressed) using the history functions (see 4.4.10).

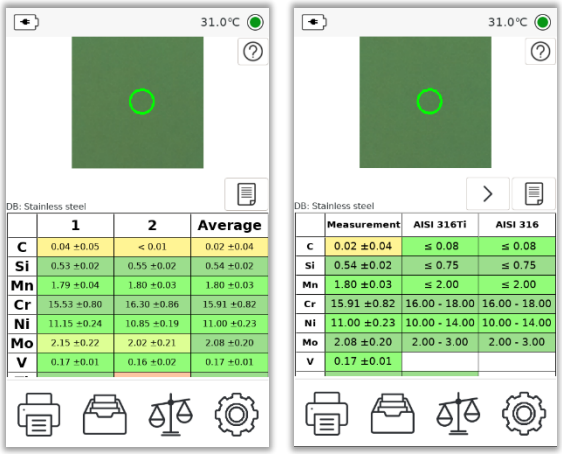


Figure 16 Measurement with multiple series averaging function. The right side shows the screen view after a short press on the measurement start button

4.6.1.7.4. Button to enable the Positioning function. When enabled, the position of the sample in front of the spectrometer hole is monitored. If the position is not correct the "sight" is displayed in red, if the position is correct the "sight" is displayed in green (Figure 17). Positioning is used to pre-fire the surface to vaporize contamination from the surface, thus reducing the error introduced by poor surface preparation. Once the correct sample position has been determined, a measurement will be taken followed by a composition determination (if a batch mode has been selected, a new measurement location will be searched).

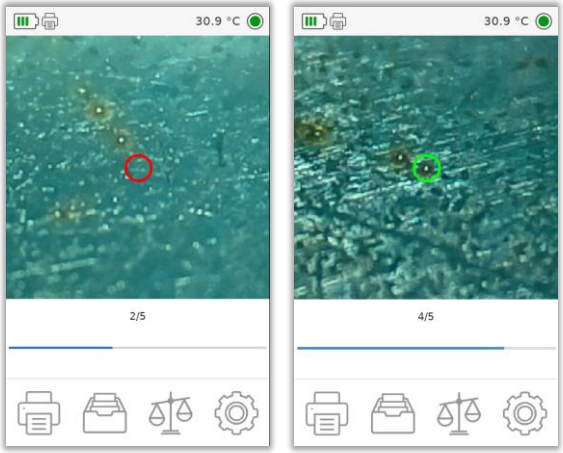


Figure 17 Measurement with function Positioning

4.6.1.7.5. Set the device to warm up for working at sub-zero temperatures and switch it off if you need to stay indoors. Clicking the "Low temperatures" button opens a window like the settings when the device is switched on. Move the sliders on the screen to select the outside temperature and planned measurement time. The device will start to warm up. The temperature to which the device is heated and the approximate waiting time will be displayed. When warm-up is finished, the message "Ready for work" will appear on the display.

At any time, you can press the "Get started" button and continue measuring, but we recommend that you do not leave the warm room until the device has warmed up. The device is ready for use when the arrows disappear.

❄	A snowflake icon will appear on the main screen to indicate that outdoor mode is in use
^25.9 °C^	When there is an up arrow near the temperature indication inside the spectrometer, it means that the device is heating up for sub-zero temperatures (up to the parameters set in the warm-up settings)

If you want to stop heating, click “Cancel” in the "Low temperatures" window.

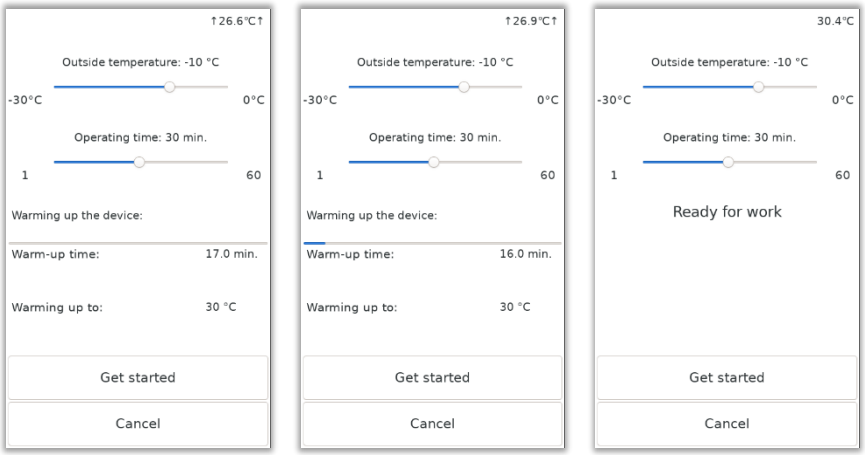


Figure 18 Window for setting the device warm-up parameters for operation at subzero temperatures

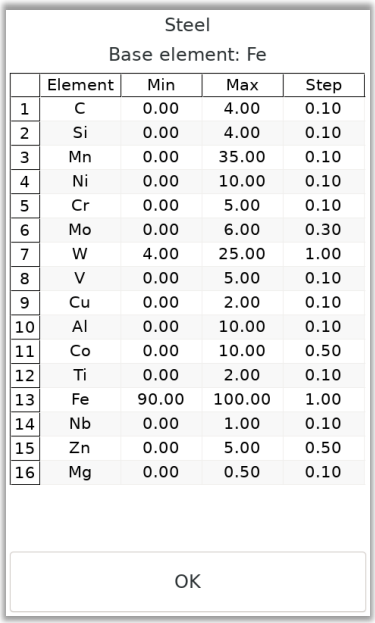
4.6.1.8. The "Group" button is used to change the name of the measurement group in the history. By default, the name of the group is equal to the current date.

4.6.1.9. "Part label" button. When you perform a measurement on the device, it is possible to set a label for it. Press the button and enter the label by which you can identify the performed measurement. The label is displayed when viewing the measurement history. For more information about synchronizing part measurements with the mobile app and the ability to edit sample descriptions, see the Mobile App User Guide. See the Mobile App User Guide for more information. For information about the mobile app, see 4.7.1.

4.6.1.10. The "Advanced settings" button opens an additional menu that allows you to configure the operation of the spectrometer. See section 4.7 for details.

4.6.1.11. The database (DB) switch displays the database for which measurements are currently being performed. If the "Select database automatically" button is pressed, the device switches databases automatically when measurements are performed. To manually set the database, you must disable the "Select database automatically" button and then select the database. Click on the database name to get

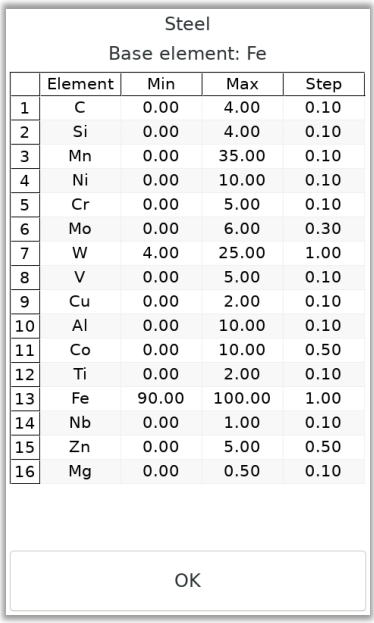
information about the database: base element, list of elements to be



	Element	Min	Max	Step
1	C	0.00	4.00	0.10
2	Si	0.00	4.00	0.10
3	Mn	0.00	35.00	0.10
4	Ni	0.00	10.00	0.10
5	Cr	0.00	5.00	0.10
6	Mo	0.00	6.00	0.30
7	W	4.00	25.00	1.00
8	V	0.00	5.00	0.10
9	Cu	0.00	2.00	0.10
10	Al	0.00	10.00	0.10
11	Co	0.00	10.00	0.50
12	Ti	0.00	2.00	0.10
13	Fe	90.00	100.00	1.00
14	Nb	0.00	1.00	0.10
15	Zn	0.00	5.00	0.50
16	Mg	0.00	0.50	0.10

determined, concentration ranges (

4.6.1.12. Figure 19).



	Element	Min	Max	Step
1	C	0.00	4.00	0.10
2	Si	0.00	4.00	0.10
3	Mn	0.00	35.00	0.10
4	Ni	0.00	10.00	0.10
5	Cr	0.00	5.00	0.10
6	Mo	0.00	6.00	0.30
7	W	4.00	25.00	1.00
8	V	0.00	5.00	0.10
9	Cu	0.00	2.00	0.10
10	Al	0.00	10.00	0.10
11	Co	0.00	10.00	0.50
12	Ti	0.00	2.00	0.10
13	Fe	90.00	100.00	1.00
14	Nb	0.00	1.00	0.10
15	Zn	0.00	5.00	0.50
16	Mg	0.00	0.50	0.10

Figure 19 Information about Steel Database

4.6.1.13. The composition and structure of databases are metrologically significant components of the firmware. Update or change of the database is made by the Manufacturer in agreement with the Customer.

4.6.1.14. The "Select DB automatically" button is intended for enabling the automatic selection of a suitable database. For example, it allows you to automatically select a "Steel" database of settings for black steels if the iron content of the sample exceeds 90%.

4.7. Advanced settings

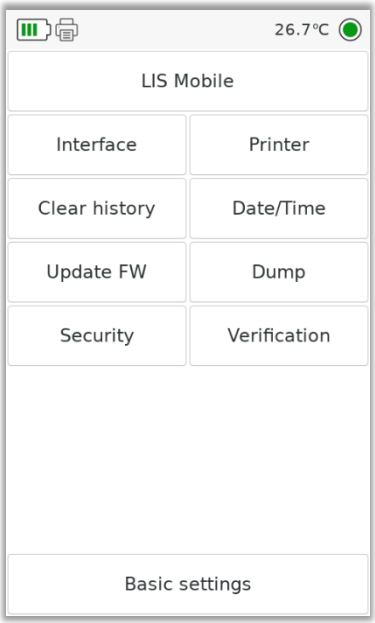


Figure 20 Advanced spectrometer settings

The "Advanced settings" button opens an additional menu:

4.7.1. "LIS Mobile" - opens additional menus for working with the mobile app.

4.7.1.1. The LIS Mobile software for Android smartphones is free of charge. After installing the LIS Mobile software on your smartphone, you get the following features:

- Use your smartphone screen as an external display for viewing the device's camera image and measurement results;
- Ability to add a description, photo of the sample to the measurement;
- Generate reports;
- Form reports;
- Edit Grade libraries;
- View measurement in the history.

More information about the features of the mobile app can be found in the user manual of the mobile app (available for download from the app itself).

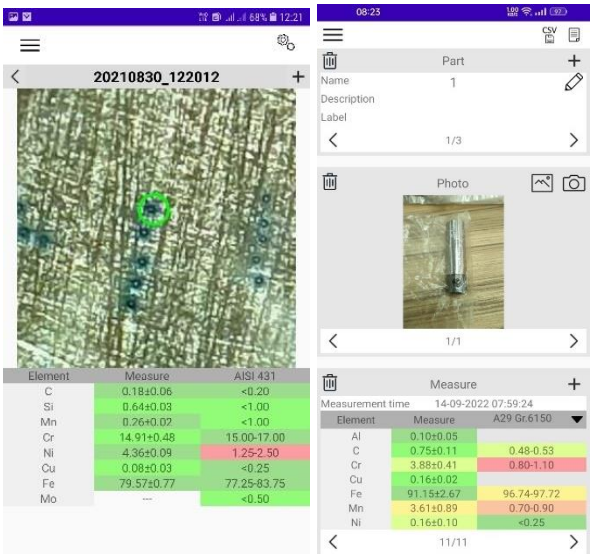


Figure 21 Work of the mobile app

4.7.1.2. The settings window for working with the LIS Mobile application has the following elements:

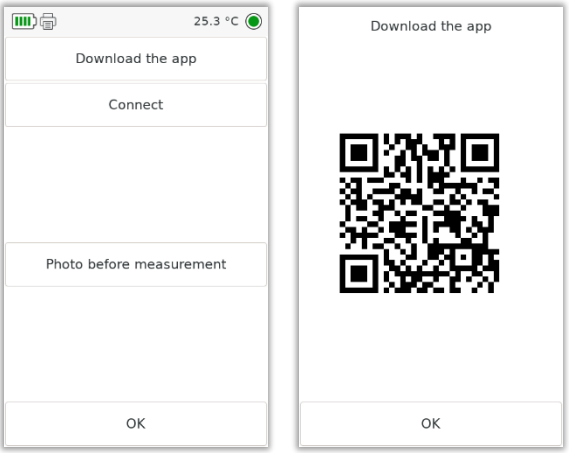


Figure 22 LIS Mobile settings window and QR code to download mobile application

To install the mobile app, click on the "Download the app" button. A QR code will appear (Figure 22), which should be viewed with the smartphone's camera (sometimes an additional software needs to be installed to read the QR code link). Follow the link and download the LIS Mobile application. Install the LIS Mobile app on your smartphone (installing a third-party application may require additional permission in your smartphone settings).

To connect to the LIS-02 device via LIS Mobile, activate the mobile hotspot on your smartphone (the smartphone will act as a modem, creating its own Wi-Fi network).

Open the LIS Mobile application. Click the Connect button.

The smartphone will give you instructions for connecting to the device:

1. On the LIS-02 device open the menu "Settings" – "Advanced settings".
2. Click the "LIS Mobile" button.
3. Click the "Connect" button.
4. At the top of the screen, the name of the network to which the Spectrometer is already connected will be displayed. If the network name does not match the access point on your smartphone, tap the Change network button.

	"Change network" button to update the list of available networks

5. In the list of Wi-Fi networks, select the access point created on your smartphone, click OK, enter the password to connect to the access point.
6. The smartphone will connect to the device.

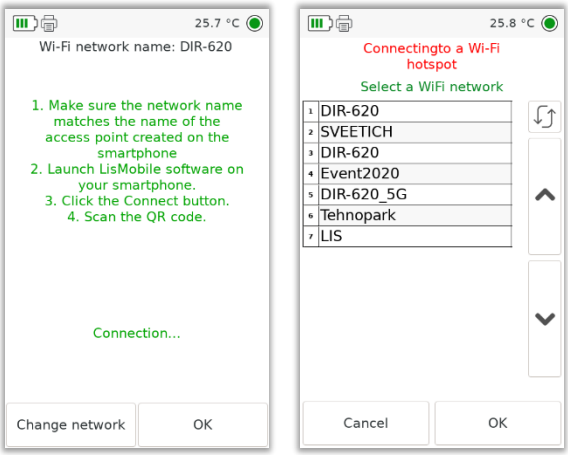


Figure 23 Connecting the Spectrometer to a Smartphone

After synchronizing the settings with the device, the camera view of the device with the scope is displayed on the smartphone screen. The measurement can now be monitored from the smartphone's screen, with the phone holder supplied with the device in a more comfortable position.

	The icon will appear on the spectrometer screen next to the battery symbol to indicate that a smartphone is connected

The "Photo before measurement" (Figure 22) button allows you to take a photo of the sample in question right before measurement by pulling the trigger on the spectrometer (hold the trigger before measurement - the smartphone activates the camera mode, make sure all relevant elements and captions are captured in the photo, release the trigger. Now take the usual measurement of the photographed sample. A measurement record will be created in the LIS Mobile app with the photo attached.

4.7.2. "Interface" - opens additional menu of interface setting.
The interface settings window has the following elements:

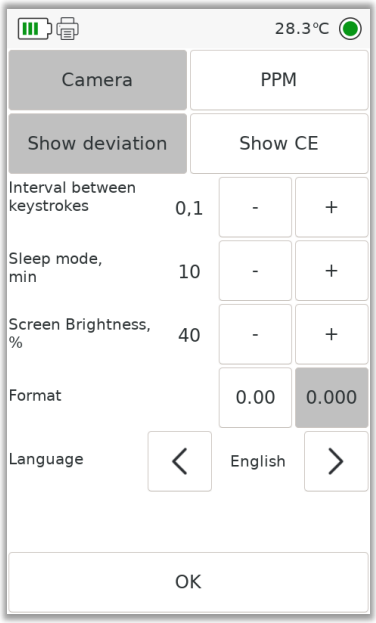


Figure 24 Interface settings window

4.7.2.1. "Camera" - turn on/off the camera and its backlight. The camera allows visual control of the control area on the sample surface and more accurate positioning of the spectrometer on the controlled surface.

4.7.2.2. The "PPM" button allows the measurement results to be obtained in PPM, not as a percentage.

4.7.2.3. "Show deviation" – display deviation of measurement in batch.

4.7.2.4. "Show CE" allows to enable/disable the display of the carbon equivalent for the rapid assessment of the weldability of steels for each measurement performed. For determining the carbon equivalent value the following International Institute for Welding formula (EN 10025-1:2004 p.10) shall be used:

$$CE = C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Ni+Cu}{15} \quad (3)$$

CE – carbon equivalent,

C – carbon concentration,

Mn, Cr, Mo, V, Ni, Cu – alloying element concentration.

Table 6 shows the conditional division into weldability groups and the coloring of the result by the device.

Table 6 The marker color of the resulting carbon equivalent for steels

CE	Weldability
<0.35	Excellent
0.35-0.40	Very good
0.41-0.45	Good
0.46-0.50	Fair
>0.50	Poor

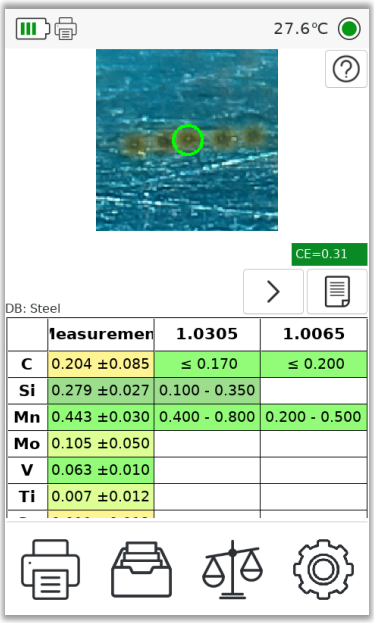


Figure 25 Measuring steel with carbon equivalent display

4.7.2.5. Items for setting the delay interval between click buttons on the menu. Increasing the delay time can be useful when using a cover and gloves to eliminate false alarms. When working in the laboratory, the delay

can be set to 0. The interval can be adjusted by clicking the "+" and "-" buttons.

4.7.2.6. Elements for setting the time when the device goes to sleep. To turn off the sleep mode with the "-" button, set the parameter value to "Off". To wake up the device from sleep mode, pull the trigger several times or touch the screen.

4.7.2.7. Screen brightness adjustment elements.

4.7.2.8. Measurement display format: two or three decimal places.

4.7.2.9. Click the left/right arrows to select the device interface language. Possible options: Russian, German, English, Vietnamese. To apply a language, select it from the available ones, click the "OK" button and reset the device.

4.7.3. The "Printer" button is required to force the printer to connect to the network. You may need it if for some reason the device is unable to communicate with the thermal printer.

4.7.4. "Clear History" - deleting all history records.

4.7.5. Date and time setting button.

4.7.6. "Update FW" - uploading a new version of the software received from the manufacturer to the spectrometer. To update the firmware, it is required to have a Wi-Fi network with Internet access. After downloading the update, press "Install" to restart the device and install the downloaded changes. To not apply the update, click "Cancel".

Attention! Downloading of the update is possible only after agreement with the manufacturer - the update is prepared for each device individually.

4.7.7. "Dump" - recording and sending service information to the manufacturer for remote diagnostics and device operation parameters settings. When sending the dump, you can select the data transfer method: via Bluetooth or Wi-Fi network (Figure 26). If you select Bluetooth data transfer, the device will offer a list of available devices, and then send a file to the selected device with zip extension, which should be sent to the technical support service to support@nppsd.ru. When sending, specify the reason for sending data from the device and contacts for communication.
If you choose to send the dump via Wi-Fi, the device will offer a list of available networks. Select the desired network, enter the password of this network. The spectrometer will connect to the server and upload the data for support. Since there is no record of your contact information when sending, please contact the technical support.

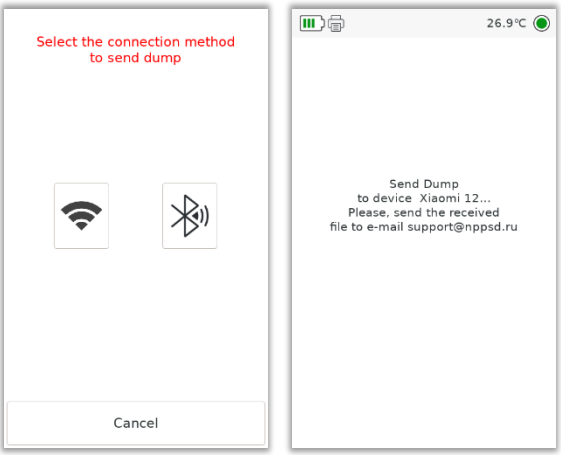


Figure 26 Sending the dump

4.7.8. "Security" – setting a password for different actions with the device. The following options are available: password to turn the device on, password of the Settings menu, administrator password (Figure 27).

4.7.8.1. The password to turn on the device will be requested each time the firmware is started (restarting the device or turning it on).

4.7.8.2. The access password to the Settings menu is requested to go to the device settings when the button Settings is clicked.

	Button for basic spectrometer settings

4.7.8.3. The administrator's password is required to limit the people who can send information from the device (sending Dump and messages through the question mark button) or updates to the device.

4.7.8.4. In the password-setting screen, you can select "Remember password". After restarting the spectrometer, you will need to enter your password again (Figure 27). If the "Remember Password" button is not clicked, the device will request a password each time it tries to perform a password-protected action.

4.7.8.5. To avoid using a password, leave the password field blank (if you change the administrator password, you must first enter a valid password).

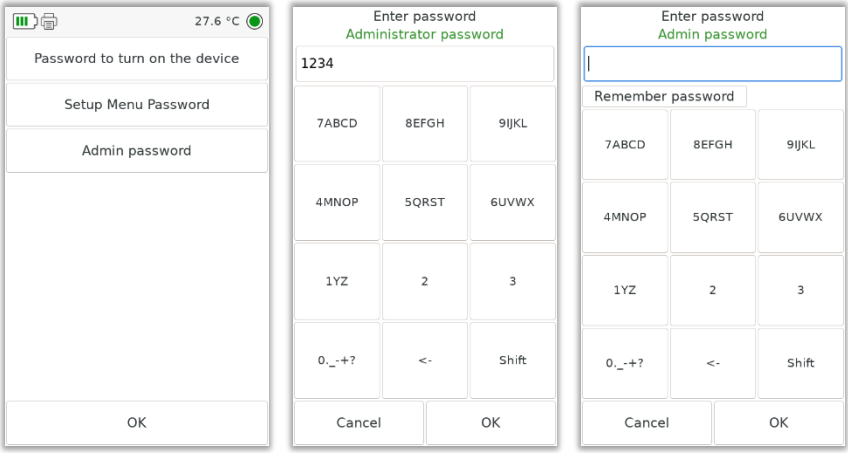


Figure 27 Security window, set and check the password to access the settings

4.7.9. "Verification" - perform the function of verification of the device (see 4.10).

4.8. Calibration

4.8.1. The calibration function is designed to increase the accuracy of the quantitative analysis of the spectrometer.

4.8.2. It is recommended that calibration be carried out if user alloy samples for which the exact chemical composition of the certified reference material is known are quantified in excess of the permissible measurement error. For example, recalibration may be required due to changes in ambient temperature.

4.8.3. If you have a pair of samples, you can perform sequential measurements of each of them by recalibrating the concentration scale of the desired elements.

4.8.4. In order to ensure the metrological accuracy of the subsequent measurements, it is recommended to calibrate at least two samples with different concentrations of impurities and approximately the same base content.

4.8.5. A calibration list is generated for each database, since the databases contain individual setting information for each class of articles to be monitored (see 4.6.1.11 for details).

4.8.6. The selected samples for calibration shall be stored as standards (see 4.11 "Etalons").

4.8.7. In the Calibration mode the user can select a previously saved calibration (edit it) or create a new one for the selected database.

4.8.7.1. Selecting a previously saved calibration.

- Click the "Settings" button, then "Calibration" button.
- Select a saved calibration by clicking on the line with its name.
- Click the "OK" button.

4.8.7.2. Creation of a new calibration.

4.8.7.2.1. Click the "Settings" button, then "Calibration".

4.8.7.2.2. Create a new calibration.

+	Button for creating a new calibration

4.8.7.2.3. Enter the name of the new calibration and click "OK" (Figure 28).

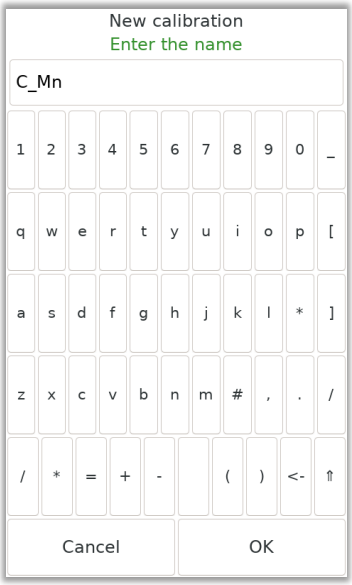


Figure 28 Window for entering the calibration name

4.8.7.2.4. Set the calibration parameters.

The Calibration Parameters Setup window contains the following items (Figure 29):

- Calibration name field.
- Minimum and Maximum Temperature Editing Elements. The parameters are applied when the automatic temperature calibration selection mode is enabled (see 5.8.7.5). Calibration will be automatically enabled if the device temperature falls within the specified range. If the calibration is to be used only for manual selection, the parameter values can be set to 0. Button to set the current temperature allows you to set the temperature of the device and 1 degree higher.
- Table of chemical elements to be calibrated. The calibration data will be calculated for the elements marked in the table in green. To select a row in the table, press the screen or the corresponding up/down button.

	Button for editing the calibration name
	Button for marking an element for calibration. The line is colored green. The same button is used to deselect the element - the color changes to the background color
	Button to view calibration for an element. Active if calibration has been performed previously for a certain chemical element. See 4.8.7.3 for details
	Button to enter the current temperature of the device, which is visible at the top of the screen when measuring

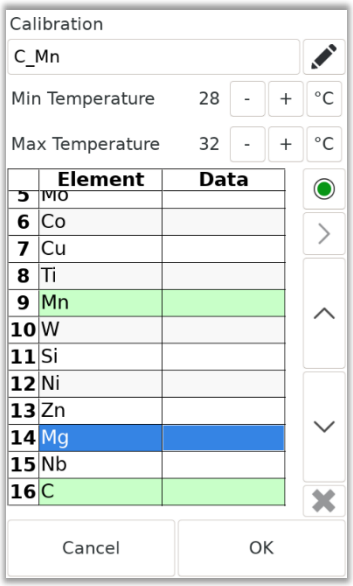


Figure 29 Calibration parameters adjustment window

4.8.7.2.5. Click the “OK” button. Depending on the selected chemical elements, the firmware will offer a list of etalons.

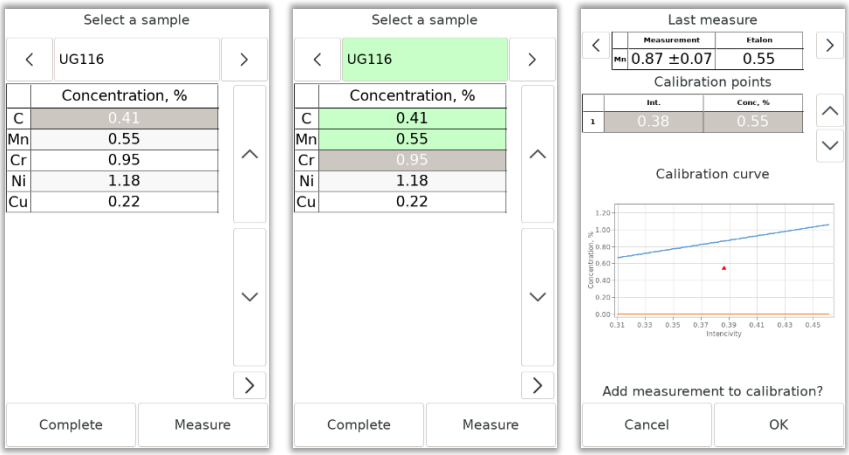


Figure 30 Etalons selection window and viewing the calibration information

4.8.7.2.6. In the Etalon selection dialog box, click the left/right button to select the first sample. To change the list of etalons and/or to change their composition, refer to the chapter 4.11 "Etalons".

4.8.7.2.7. Click "Measure" button.

4.8.7.2.8. Take a batch mode of samples.

4.8.7.2.9. The following information will be displayed in the last measurement data window when the survey is completed:

- Element, concentration and SD of a given measurement according to the current calibration, the reference value for the selected sample.
- The table with the obtained values of intensity and concentration for building the dependence of the new calibration.
- Type of the calibration curve. The blue color indicates the current dependence. Red is the new one obtained from the points you have measured (**no line is drawn through one point**).
- The "Cancel" button removes the points from the calibration. The "OK" button adds the obtained measurement to the calibration.

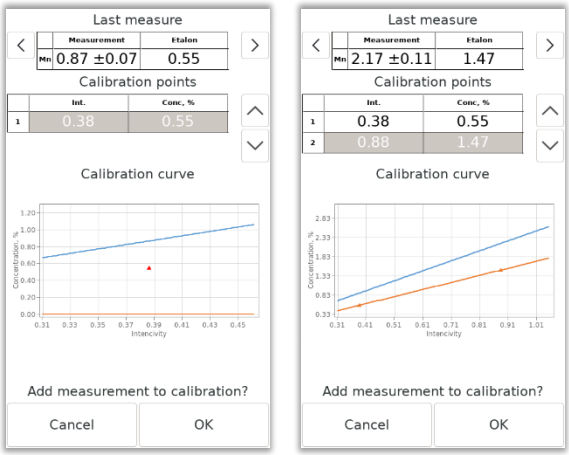


Figure 31 View last measurement information for one and two measurements

4.8.7.2.10. After adding a point to the calibration or removing it, you will be asked to select the next sample. Samples that have been measured for calibration will be highlighted in green. The rows of elements are colored green - these concentrations are saved in the calibration (Figure 30).

4.8.7.2.11. In the etalon selection window for each element you can view the list of points and type of calibration curves. To do this, select the element in the etalon selection window and click the button to view more information (Figure 30).

	Button to view additional information

4.8.7.2.12. To continue the calibration by the next sample repeat the steps 4.8.7.2.6 - 4.8.7.2.10, to finish the calibration press the "Complete" button.

4.8.7.3. Change a previously saved calibration.

- Click the "Settings" button, then "Calibration" button.
- Select a saved calibration by clicking on the line with its name.
- Click the calibration edit button.

	Calibration edit button

- The Calibration Settings dialog box allows you to change the calibration name, minimum and maximum temperature for automatic calibration selection (Figure 32).
- If calibration data already exist for the chemical element, the element string contains the entry "In the DB". The calibration points and the calibration curve can be viewed by clicking on the calibration view button for the element (Figure 32). To exit the window of the calibration curve view, click "OK".

	Button to view the saved calibration for the element

- To delete previously saved calibration data of an element, highlight the necessary line and press the delete calibration data button.

	Calibration data deletion button

- Select the rows of chemical elements for which you want to add/change calibration data with the selection button (see 5.8.7.2.4) and press the "OK" button.
- Perform the measurements of the etalon samples in the same way as described in 5.8.7.2.6 - 5.8.7.2.10.
- To cancel changes made to the calibration, press "Cancel".

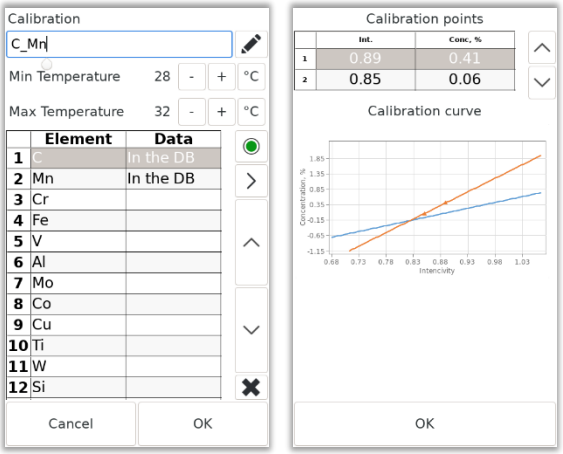


Figure 32 Changing the calibration parameters

4.8.7.4. To disable additional calibration and use the manufacturer's parameters, select "None".

4.8.7.5. To automatically select a calibration based on the device temperature, press the Auto Select by Temperature button. Calibrations with temperature ranges are highlighted in green (Figure 33). The calibration that is active at the current temperature inside the device will be highlighted in bold. Press the "OK" button.

°C	Button for automatic selection of calibration, depending on the temperature inside the device

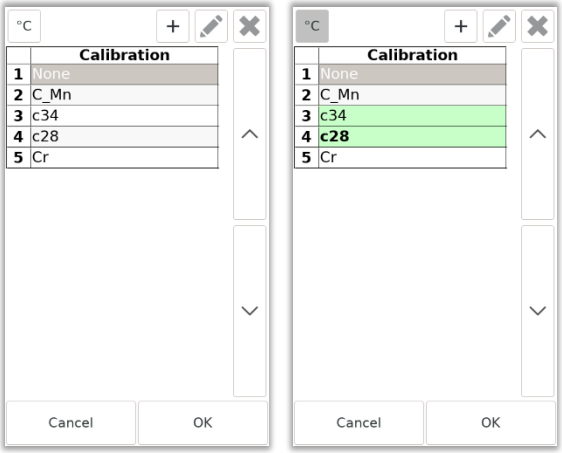


Figure 33 Calibration selection window

4.9. Grade library editor

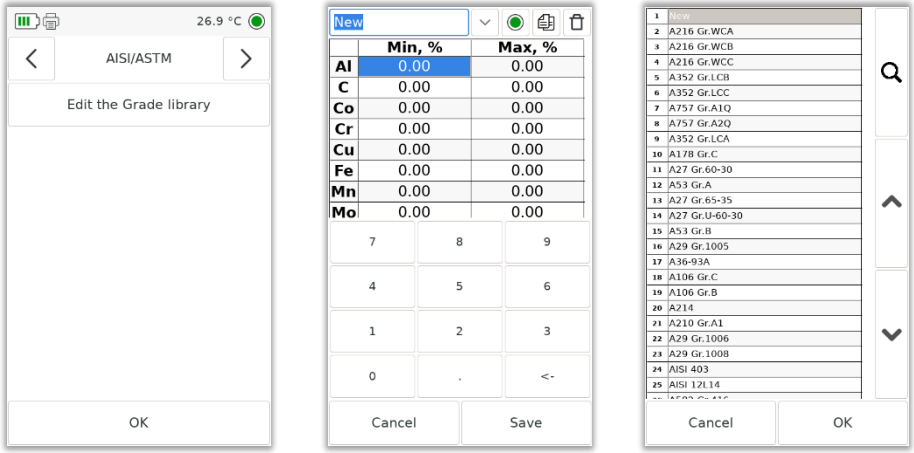


Figure 34 Editing the Grade library

4.9.1. To open the Grade library editor, click the "Grade library" button in the advanced settings.

4.9.2. If there are several Grade library (e.g., Basic and AISI/ASTM), select the one you want by using the right/left arrows. Click the "Edit the Grade library" button (Figure 34) to go to edit or add grades.

4.9.3. To add a new grade:

- Select the line with the name "New".
- Change the name of the grade (If you select this window, the on-screen keyboard will change to the character keyboard).
- Change the element concentrations (the on-screen keyboard will change to a numeric keypad).
- The elements whose concentration is taken into account in the grade search are highlighted in green (automatically highlighted when the concentration is added). It is possible to exclude one or more elements included in the grade from the search conditions.
- To exclude an element from the search (make it optional for the grade), click the check/uncheck button. The line will cease to be green. This may become necessary for an element that has a concentration range for material greater than zero and less than 0.1. The sensitivity of the device is insufficient to distinguish such concentrations from zero

and as a result may not show such a grade, thinking that it has not found the required element.

	Check/uncheck button to take the element into account when searching for a grade

Attention! Note the need to enter the element that is the base of the alloy.

- Click the "Save" button to save changes, and the "Cancel" button to exit the Grade library without saving changes.
- If you corrected the Grade library, and then want to add a grade, select the first line with the name "New" in the list of grades. Then proceed as in the beginning of section 4.9.3.

	Button to display the list of grades in the Grade library

4.9.4. To copy a grade from one Grade library to another Grade library:

- Select the Grade library from which you want to copy the grade.
- Open the list of grades stored in the Grade library using the button displaying the list of grades.
- Select the necessary grade (you can search for a grade by name using the magnifying glass button).
- Press the copy button.

	Grade copy button

- Select from the suggested list the Grade library to which you want to copy the selected grade.
- Press the "OK" button to finish the copying.
- If you want to cancel the operation, click "Cancel".

4.9.5. To change the composition of a brand:

- Select the grade for editing using the button for displaying the list of grades in the Grade library (section 4.9.4). You can search for a grade by name using the magnifying glass button.

	Search by grade name button

- To proceed to the editing of the grade, press "OK". To return press the "Cancel" button.

- Select the desired cell with the concentration you want to correct for the grade. If the element you want is located below, swipe up from the bottom of the screen (similar to a smartphone touchscreen) and the other elements will be in the visible area.
- Editing the concentration is done by clicking on the desired cell and entering a number using the numeric keypad buttons (Figure 35).
- The edited area is highlighted in gray.

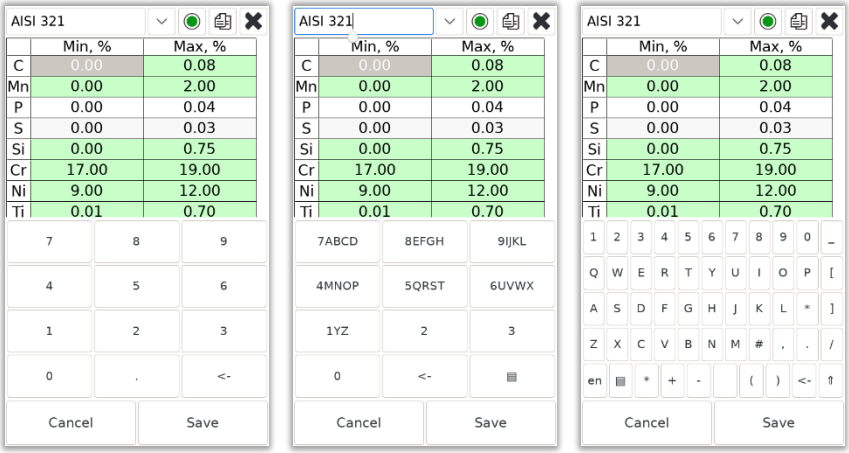


Figure 35 Editing the grade of the selected grade library

- To change the grade name, click on the field with its name, the numeric keypad will change to a symbolic keypad, and the name itself will be highlighted with a blue frame (Figure 35).

	Button to change the appearance of the character keyboard

- The first type of keyboard has large buttons for easier use without a stylus. Some keys have multiple characters on them - hold down the key to change the character (Figure 35).
- On the keyboard with separate buttons (Figure 35) for each letter you can also insert some symbols, change the case (upper or lower case), select the keyboard language (Russian or English).
- Editing the grade name is completed by pressing the "Save" button, or when selecting the table cell.

4.9.6. Removal of the grade from the grade library by clicking the delete button.

	Button for deleting a grade

4.10. Verification

The "Verification" menu is used to perform metrological verification of the spectrometer according to the approved methodology. For the standard sample, at least 10 measurements of the output signal intensity at the emission spectrum for C (193,09 nm), Cr (313.20 nm), Mn (279.48 nm), Si (288.16 nm), Ni (221.65 nm) lines are made according to the instructions on the screen. As a result of measurements for the given lines the spectrometer in the top part of the screen displays the table of intensity of an output signal, SD and sensitivity. In the lower part of the screen the spectral resolution is displayed at the wavelength of 221.65 nm.

The main verification means is a certified reference sample of alloyed steel УГ35б, registration number in the FIF GSS 6384-92 with certified mass fraction values of C (0.301±0.005) %; Cr (2.63±0.01) %; Mn (0.109±0.002) %; Si (0.94±0.01) %; Ni (0.84±0.01) %. It is allowed to use similar means of verification, providing determination of metrological characteristics of verifiable measuring instruments with the required accuracy.

The main metrological characteristics are given in paragraph 1.4.

4.11. Etalons

4.11.1. When working in "Comparison with etalon", "Calibration" modes, it is necessary to specify the elemental composition of samples. To make this purpose easier, a list of etalons is used. It allows you to define and store in the device memory the compositions of the used reference etalons in advance.

4.11.2. To edit the list of etalons, you should click the "Settings" (Figure 14) button and select the "Etalons" button.

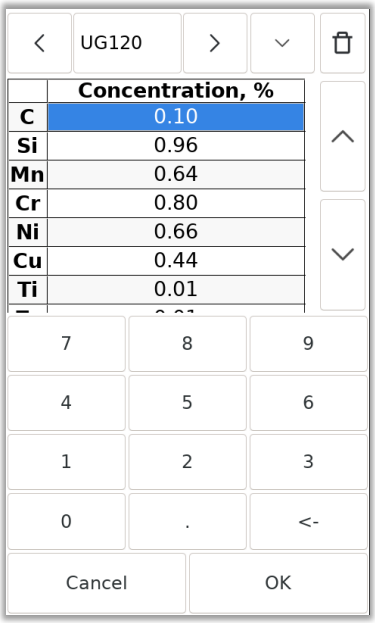


Figure 36 Etalon selection and editing window

4.11.3. For each database a different list of etalons is used.

4.11.4. You can select the etalon for editing by clicking the left/right arrows.

4.11.5. To change the etalon:

- Select the element you want to change.
- Use the numeric keypad buttons to enter the concentration.

4.11.6. To create a new etalon:

- Click the left/right buttons to select a row named "New".
- Clicking an etalon name field replaces the numeric keypad with a symbolic keypad - enter the name of the new etalon.

- Set the concentration of the sample elements. The set of elements depends on the database selected in the settings.

4.11.7. Delete the etalon by pressing the corresponding button.

	Button for removing the etalon

5. Storage and operation of the product

The spectrometer must be operated in accordance with this user manual.

The seals and labels affixed by the manufacturer must be retained throughout the warranty period.

Do not work with unprotected device in the rain.

The device is transported in closed vehicles of any kind, according to the Rules of transportation operating on each type of transport, at an ambient temperature from -30 to +70 °C and relative humidity up to 95 % at temperature +25 °C.

The device should be stored in warehouses at ambient temperature from -30 to +70 °C and relative humidity of 80% (at temperature +25 °C).

The device may be put into operation after a long period of storage at low temperatures only after a process pause in the room in which it is operated.

For operation or warranty questions please contact the service department of OOO "NPP "STRUCTURAL DIAGNOSTICS" ("Structural Diagnostics" Research and Production Enterprise, LLC) by phone +7 (343) 319-12-62 or e-mail mail@nppsd.ru.

6. Disposal information

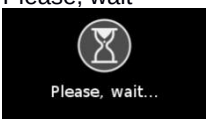
The product does not present any danger to life, human health or the environment after it has reached the end of its useful life.

Disposal is carried out by the consumer in accordance with the general requirements for the disposal of electronic (computer) equipment.

Annex 1. Possible malfunctions and troubleshooting methods

Description of the fault	**Possible reason**	**Methods of elimination**
The spectrometer does not turn on. LCD display does not light up	Battery is discharged	If necessary, charge the batteries
The device is switched on, but the screen does not turn on or respond to touching	The spectrometer has gone into sleep mode	Click the measurement start button (trigger) on the device and then tap on the display

Annex 2. Possible error messages and their causes

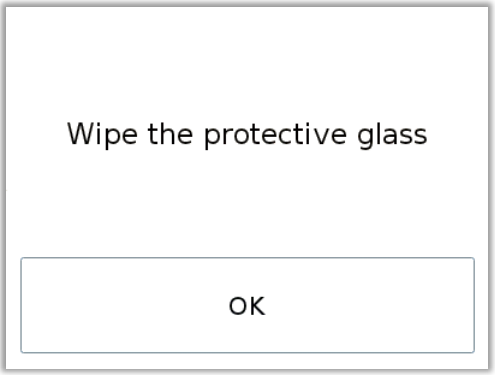
Error message	Possible reason	Methods of elimination
After measuring a reference sample (RS), the corresponding grade is not displayed.	Battery is discharged	Charge the batteries or replace them with a high level of charge.
	Poor fit of the RS to the inlet opening.	Ensure that the specimen is in good contact with the device.
	Contamination of the safety glass	Clean (see Appendix 3) or replace the protective glass (see Service manual).
	Trouble with RS (substitution)	Replacement of RS or re-certification of RS.
	Failure of the device	Contact the manufacturer in accordance with the warranty/guarantee service regulations.
Low signal level. Wipe down the protective glass. Repeat the measurement of the reference sample.	Contamination of the safety glass.	Clean (see Appendix 3) or replace the protective glass.
	Poor fit of the sample to the inlet opening.	Ensure that the specimen is in good contact with the device.
	The surface of the sample has contamination.	Sand the surface with sandpaper or other special tools.
You're about to run out of free space on your device. Contact support.	There is a lot of information stored in the device's memory.	Call Technical Support or email support@nppsd.ru with a description of the problem.
Communication with the controller is lost. Shut down the Spectrometer and remove the batteries. Restart the device.	An error occurred in the process of data transfer from the spectrometer unit.	Shut down the Spectrometer and remove the batteries. Restart the device. When using batteries, try replacing them with other ones.
Please, wait 	Spectrometer goes into working mode when the device is switched on or the delay is changed.	Wait until the warning window disappears.

	Long working with function Positioning.	Stop measuring, wait until the message disappears. Continue work. Measurements made during the message are invalid.
Please, wait (not in single window).	An error has occurred in the data transfer process from the spectrometer unit.	Wait 30 seconds and repeat the measurement. If the error message does not disappear, restart the device.
Low temperature. The measurement error may increase. To evaluate the error, perform a RS measurement.	The temperature inside the device has fallen below the possible operating temperature (the temperature is displayed at the top of the screen).	Perform a RS measurement. Evaluate the result for further work.
The temperature of the device has been exceeded. Continued operation may cause measurement errors. Turn off the power to the device for 30 minutes.	The temperature inside the device housing has become higher than the possible working temperature.	Complete the measurements. Switch off the device (unplug the power supply). Wait approximately 30 minutes (to speed up the cooling process, you can place it in a cooler room).

Annex 3. Wiping the protective glass

It is recommended to wipe the protective glass before each start of work with the spectrometer. As a rule, it is enough to slip a cotton bud through the spout opening of the device and wipe the glass.

The device reminds you to wipe the protective glass so that you do not forget to do so.



Annex 4 Wide spout cover

A wide spout cover can be used to improve the fit on large flat samples.

Unscrew the two screws on the spout, remove the narrow cover and install the wide cover on the same two screws.

Annex 5. Manufacturer's warranty

Manufacturer

Name of the company: OOO NPP "STRUCTURAL DIAGNOSTICS" ("Structural Diagnostics" Research and Production Enterprise, LLC)

Legal address (used in invoices, etc.):

Russia, 620092, Yekaterinburg, Constructorov St. 5, office 303

Mailing address (used to send mail):

Russia, 620092, Yekaterinburg, Constructorov St. 5, office 303

INN/KPP 66704777270/ 667001001

Phone/fax +7 (343) 319-12-62

OGRE 1196658001297

Requirements for operating conditions

Ambient temperature range: minus 10 to plus 40 °C.

Relative humidity of air: no more than 98 % at 20 °C without condensation of a moisture.

Do not use it in rain or wet snow.

When using the spectrometer stationary, install it in a place protected from flooding by water or other liquids.

Avoid contact of the spectrometer body with chemically active liquids and gases.

Do not install or remove the spectrometer outside the authorized center.

Manufacturer's warranty

The manufacturer provides a 24-month warranty on the spectrometer to which this Warranty Card was issued at the time of purchase.

Attention! ***Important information for consumers:***

The warranty does not cover the galvanic elements in the device.

The Manufacturer is not responsible for any defects of the spectrometer if they occurred after the transferring of the spectrometer to the consumer due to violation of the rules of installation, use, transportation, storage, actions of third parties, force majeure (fire, natural disaster, etc.). Other foreign influences (e.g. electromagnetic radiation or static electricity) and violations of the technical requirements specified in the operating instructions and in the Terms and Conditions for Termination of Warranty of this warranty card.

The manufacturer declines all liability for possible damage caused directly or indirectly by the products of OOO NPP "STRUCTURAL DIAGNOSTICS" if it is

caused by failure to observe the rules and conditions of operation, installation of the product, intentional or careless actions of the consumer or third parties.

On questions of operation, warranty and post-warranty service you may contact the service of OOO NPP "STRUCTURAL DIAGNOSTICS" by phone +7 (343) 319-12-62 or e-mail mail@nppsd.ru.

Terms of termination of warranty obligations

- Violation of transport, storage, installation and operating conditions.
- Mechanical damage to the spectrometer body, internal modules, elements, conductors, punctures, punctures and damage to connecting cables, antenna body, warranty stickers, seals and other mechanical damage.
- The presence of traces of unskilled repair attempts.
- Presence of changes in the spectrometer design, not provided by the Manufacturer.
- Damage caused by foreign objects, liquids, liquids, animals or insects entering the body of the spectrometer.
- PCB, radio, and spectrometer modules are not installed as a result of oxidation or ignition.
- Installation and maintenance of the spectrometer by non-qualified personnel.
- The use of the spectrometer is not for its intended purpose.
- Unauthorized interference with the spectrometer's firmware.
- Changes to the software and spectrometer settings resulting in malfunction of the spectrometer.

Annex 6. Passport of a reference sample

ЗАКРЫТОЕ АКЦИОНЕРНОЕ ОБЩЕСТВО
ИНСТИТУТ СТАНДАРТНЫХ ОБРАЗЦОВ

аккредитовано в соответствии с требованиями Руководства ИСО 34:2009 (ISO Guide 34)
(аттестат аккредитации № ААС.RM.00173)
ул. Ульяновская, 13а, г. Екатеринбург, Россия, 620057
iso@icrm-ekb.ru; www.icrm-ekb.ru; тел. (343) 228-18-93

Лист № 1
Всего листов 3

ПАСПОРТ

стандартного образца утвержденного типа

ГСО 6382-92 – 6386-92

УГ33б – УГ37б

Наименование: стандартные образцы состава сталей легированных типов 5Х2МНФ, 40ХН2Л, 3Х2МНФ, 20ХН4ФА, 5ХНМ (комплект СО УГ33 - УГ37).

Назначение: стандартные образцы предназначены для градуировки средств измерений при определении состава сталей (ГОСТ 5950-2000, ГОСТ 977-88, ГОСТ 4543-71) спектральными методами, аттестации методик измерений.
Стандартные образцы могут применяться для контроля точности результатов измерений при определении состава сталей (ГОСТ 5950-2000, ГОСТ 977-88, ГОСТ 4543-71), для поверки (калибровки) средств измерений при условии соответствия их метрологических и технических характеристик критериям, установленным в методиках поверки (калибровки) соответствующих средств измерений.

Метрологические характеристики:
Аттестованные характеристики - массовая доля элементов, в процентах:

Индекс СО	C	Si	Mn	Cr	Ni	Mo	V	Cu
УГ33б	0,39	0,155	0,89	1,45	1,93	0,075	-	0,179
УГ34б	0,215	0,34	1,61	0,31	2,61	0,39	0,71	0,263
УГ35б	0,301	0,94	0,109	2,63	0,84	0,65	0,108	0,178
УГ36б	0,324	0,234	0,206	0,94	4,32	0,140	0,215	0,067
УГ37б	0,39	0,074	0,38	0,57	1,26	0,75	0,49	0,386

Границы абсолютных погрешностей ±Δ аттестованных значений для доверительной вероятности 0,95, в процентах:

Индекс СО	C	Si	Mn	Cr	Ni	Mo	V	Cu
УГ33б	0,01	0,003	0,01	0,01	0,01	0,001	-	0,003
УГ34б	0,006	0,01	0,02	0,01	0,01	0,01	0,02	0,005
УГ35б	0,005	0,01	0,002	0,01	0,01	0,01	0,003	0,003
УГ36б	0,005	0,005	0,004	0,01	0,05	0,003	0,004	0,001
УГ37б	0,01	0,006	0,01	0,01	0,01	0,01	0,01	0,005

ИСО