Sonel ThermoAnalyze2®

USER MANUAL

v 1.1 30.11.2015

The Quality Management System ISO9001:2008 is approved for the design, manufacture and maintenance of all the measuring instrumentation manufactured by Sonel S.A.

Due to a policy of continuous development of our products, Sonel S.A. reserves the right to apply changes and improvements to the Thermal Imager and the Thermo Analyze software described in this manual without prior notice.

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1 Introduction

This publication provides the necessary information required to use Sonel ThermoAnalyze2 ® PC software, to analyze static image files and real-time video footage recorded by Sonel thermal cameras.

It is recommended that this user manual and the thermal camera's user manual are read thoroughly before using the software.

It is also advisable that all user manuals and instruction leaflets supplied are kept readily available for reference, when the software is in use.

Technical Support

Technical support for the software can be obtained on weekdays by email to the following address: hx@sonel.pl

Feedback to Us

From our side we guarantee to make every effort to ensure proper operation of the equipment and the software. In case of any changes, related to continuous development of our products, information on the changes will be available on our website www.sonel.pl/en. Additionally, you are appreciated to let us know about any error you find, and your suggestions for further editions by writing an email to the following address: hx@sonel.pl.

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2 Installing Sonel ThermoAnalyze2

Processor	Pentium4 2.4GHz or better
RAM	256M (512M recommended) or more
Free available space on hard disk drive	2GB (40 GB recommended)
Operating System	Windows XP 32 bit/64 bit or higher
Graphics Card	NVIDIA GeForce 5200 128MB or better
Additional software	Adobe Reader

It is recommended to close down all running applications before installing the program.

2.1 Sonel ThermoAnalyze2 Installation Guide

It is recommended to close down all applications before installing the program.

After inserting the CD containing the software (supplied with your camera) into CD-ROM drive, installation dialog box will appear. If the installation box doesn't appear automatically, double-click "autorun.exe" file in the CD's main folder.

After language selection, a new dialog box will appear. Choose 'Thermal Imagers',

and then ‘install Thermo Analyze 2’:

Installation process will begin. Follow the on-screen instructions.

NOTE: Without changing the default directory to install the program, the installation procedure will allow the program to be installed under C: \Program files\ Sonel ThermoAnalyze2. The installation procedure will add a shortcut icon Launch Sonel ThermoAnalyze to the Desktop and Start menu.

2.2 Driver Installation Guide

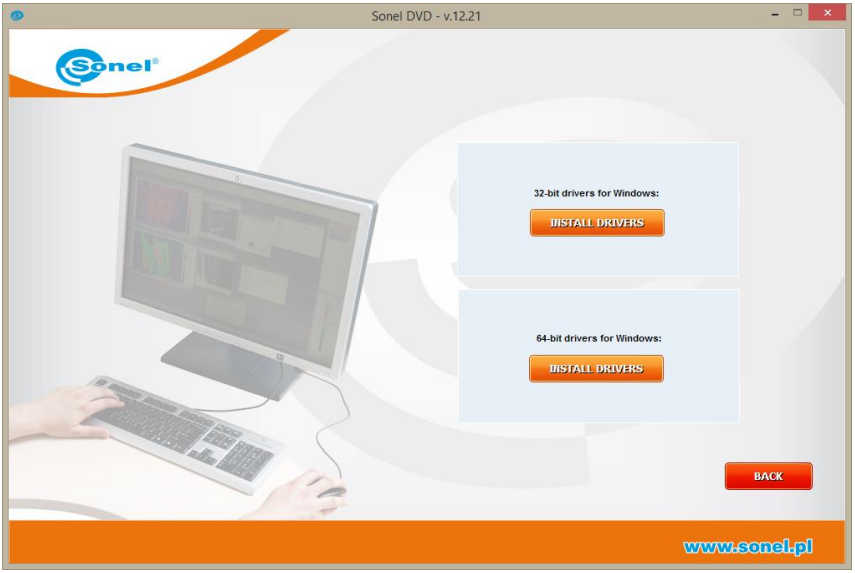
The driver should be installed automatically during Sonel ThermoAnalyze2 software installation. If it has not happened, then it must be installed manually, as described below. It is recommended to install driver before connecting thermal camera to PC.

After inserting the CD containing the driver (supplied with your camera) into CD-ROM drive, installation dialog box will appear. If the installation box doesn't appear automatically, double-click "autorun.exe" file in the CD's main folder.

After selecting language new dialog box will appear. Choose 'Thermal Imagers':

and then 'install drivers':

Choose the type of driver, depending on the operating system installed on your computer (32 or 64 bit):

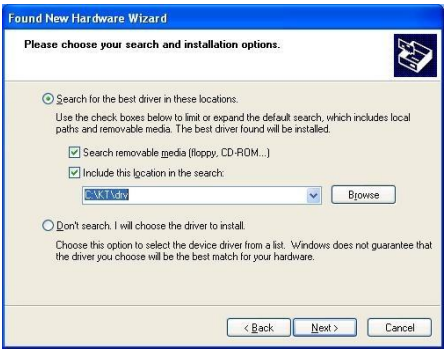


If the camera was connected to your computer before installing the driver, or the original installation CD is missing, you can perform installation process manually, using previously obtained driver files (e.g. by downloading it form our website www.sonel.pl/en). After connecting the camera to USB port in your computer, new Sonel IR device Installer will appear. Installer will ask you whether to search for new

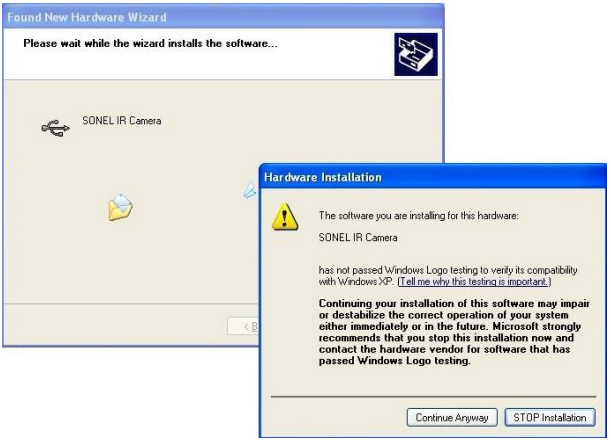
driver online or not, you need to select “no, not this time” option and click “next”. Then allow searching for the drivers automatically – the installer will search for the drivers through all data carriers:

If the driver is not found automatically choose “Install from a list or specific location (advanced)”

Then use the browser to select the folder (drive) containing the driver file, and click ‘next’ to proceed:



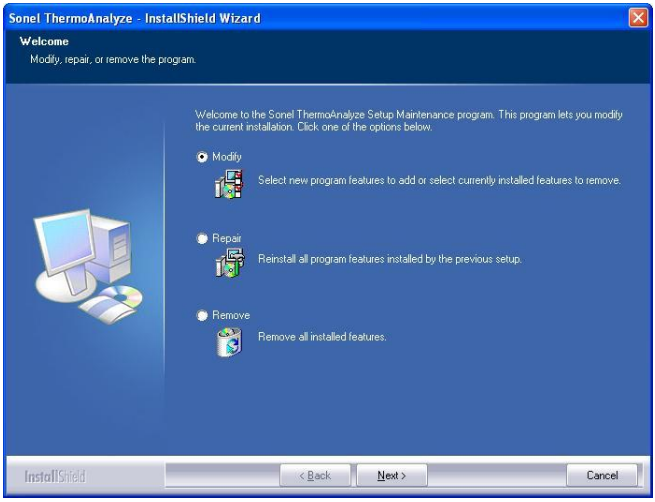
Installation begins. After reaching the stage shown below, choose ‘continue anyway’:



Dialog box will inform you that the installation process is finished. Click ‘Finish’ button’.

2.3 Uninstalling Sonel ThermoAnalyze2

Proceed similarly as in the case of installation. After a dialog box appears choose ‘Remove’ option.



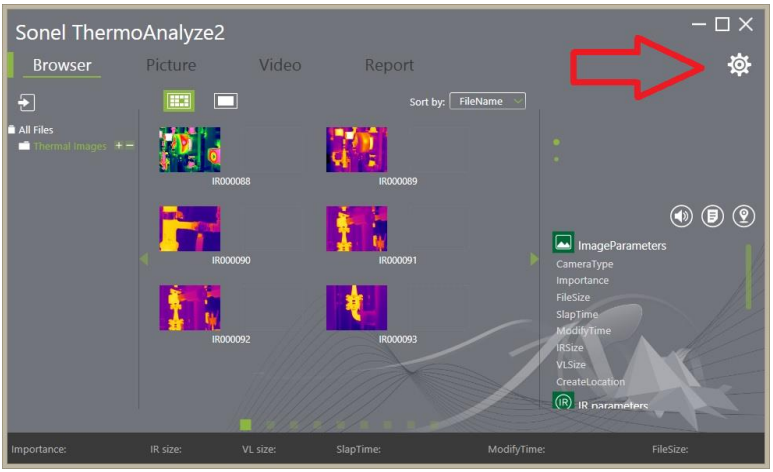
Then follow on-screen instructions.

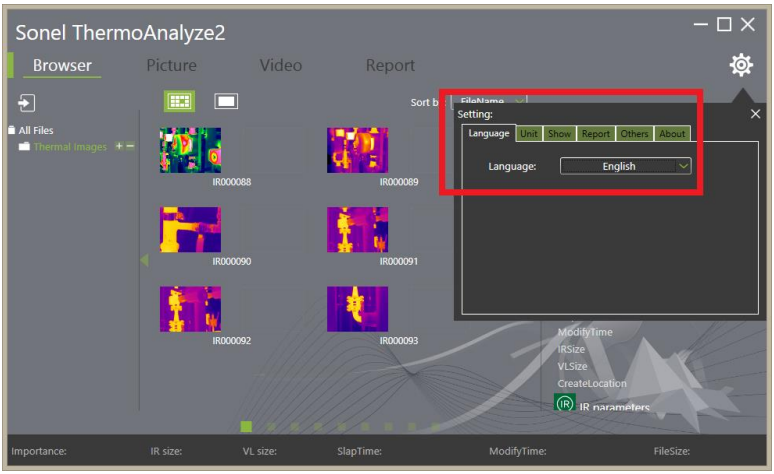
3 Using Sonel Thermo Analyze – general information

3.1 Settings

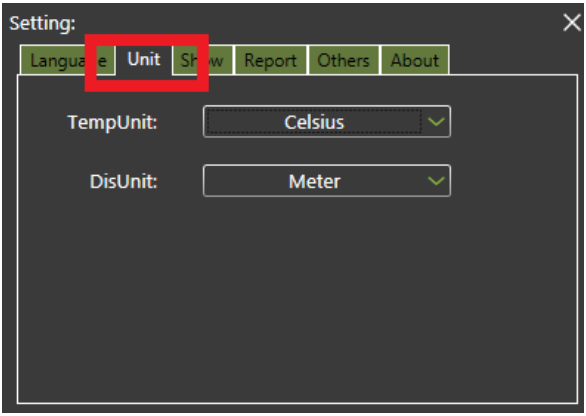
After you install the program on your PC and run it, the program will open in English as the default language.

To change the language, click **'Settings'**  icon in the right, upper corner of the screen and choose **'Language'** tab, where you can select preferred language. Selected language will be automatically set and remembered as default.

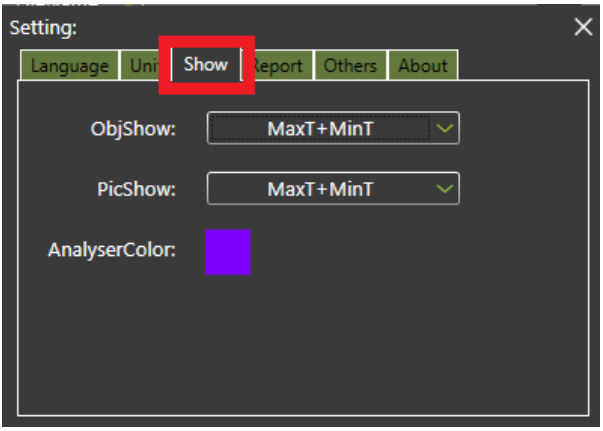




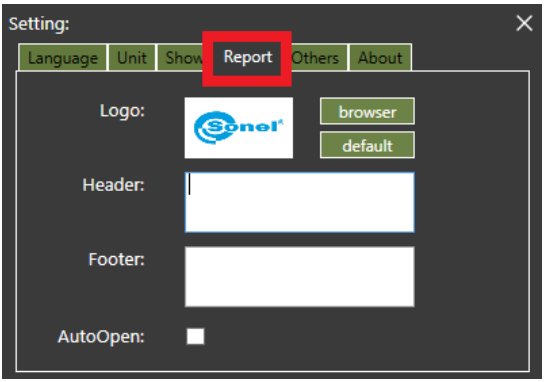
Next tab available in the Settings menu is **'Unit'** tab, that allows to choose preferred temperature unit (Kelvin, Celcius, Fahrenheit), as well as distance unit (Meter, Inch).



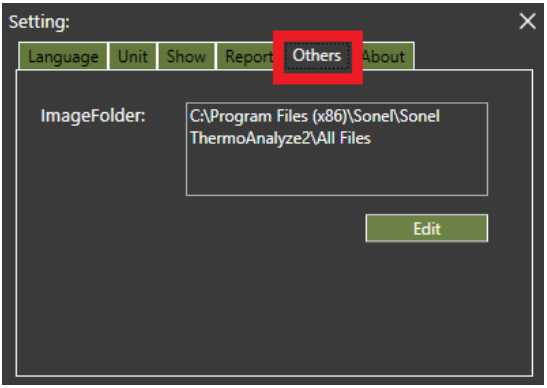
'Show' tab allows to define points that will be presented on the thermograms (Picture) and on the objects added during thermal analysis (Object). Selecting MaxT+MinT for Picture will result in adding points of highest, and lowest temperatures to the analyzed thermogram. The same effect will be achieved for added object..



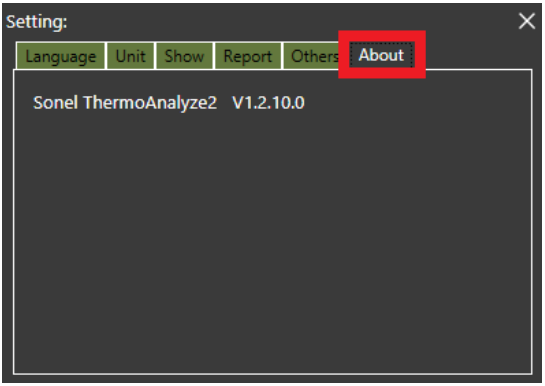
'Report' tab allows to change default logo, add default header and footer to the reports generated within Sonel Thermo Analyze2. Selecting 'AutoOpen' automatically converts and opens created report in PDF file.



'Others' tab allows to select preferred place (folder) on hard drive for storing thermal images used by Sonel ThermoAnalyze2®..

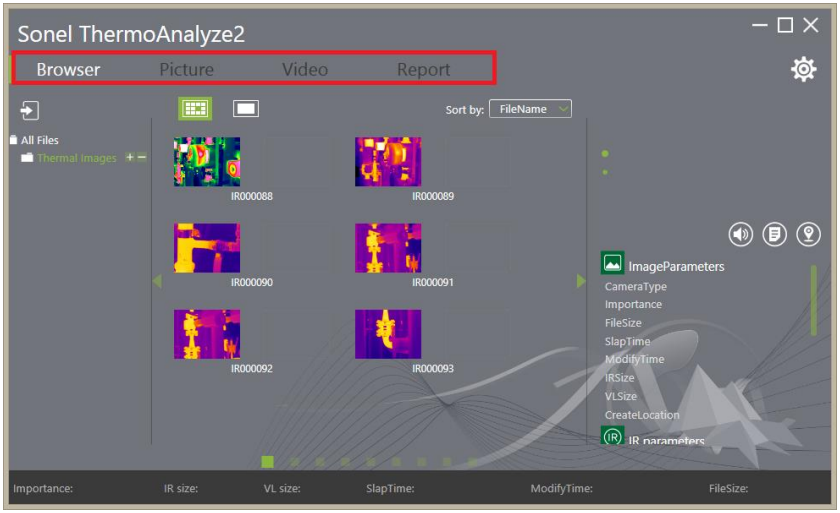


'About' tab shows installed version of the software. .



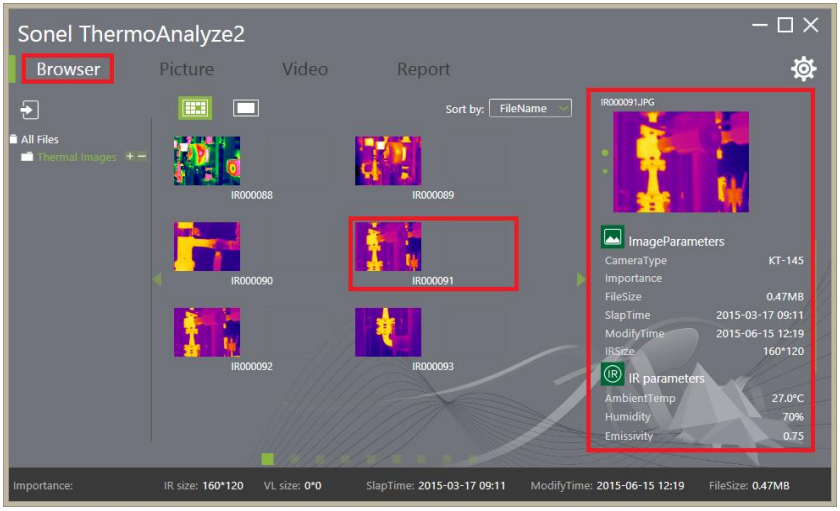
3.2 Sonel ThermoAnalyze2 interface.

After starting the program, the window below will appear. It consists of four basic parts: Browser, Picture, Video and Report.



3.2.1 Browser tab

'Browser' tab allows to import thermal images from KT series imagers (selected models) to PC, create folders for thermal images and to quick and easy preview of saved thermal images.



After selecting single picture from the list (one single click of left mouse button) the program will show, on the right side of the main screen, additional information about the selected image, such as:

Image Parameters – tells of importance, file size, date and time of when the IR image was taken (Slap Time), date and time of the last modification applied to the image and what is its resolution (IRSize).

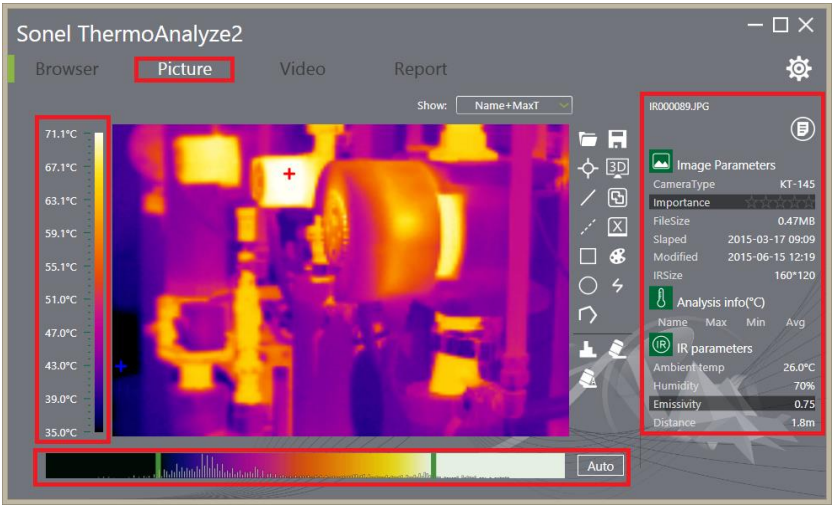
IR parameters – tells of the set ambient temperature, humidity, emissivity and distance from the measured object.

Measurement info - information about the maximum and the minimum temperature registered.

Additional properties of the selected picture are presented on the bar on the bottom of the screen.

3.2.2 Picture Tab

Second tab from the left. It allows to perform precise analysis and to edit stored IR image, before using it in a report.

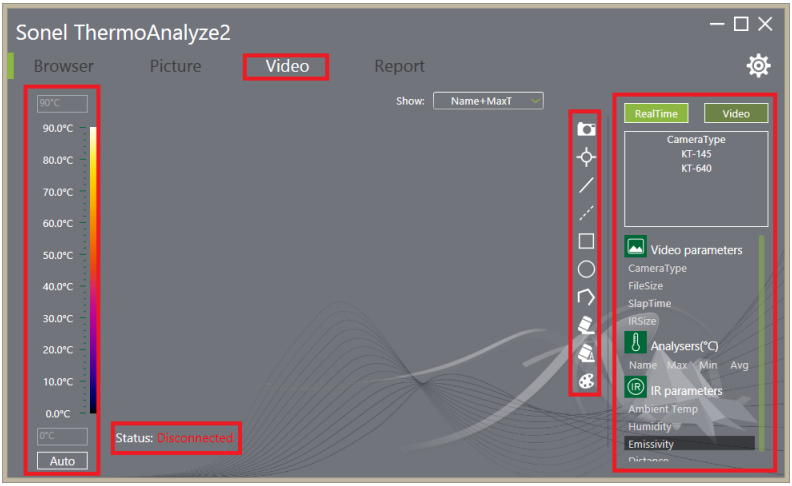


On the left side of the image, temperature scale, where different colors are representing different temperatures, is presented.
A bar, that allows to adjust graphical representation of temperature, is located below the IR image. This range (bar) is set automatically by the program based on the highest and the lowest measured temperature, however there is an option for adjusting the range manually. To change the color that is representing the highest, or the lowers measures temperature, move the mouse button over the green, vertical stripe that is visible at the beginning or at the end of the bar, press and hold the left mouse

button and move it left or right. Icon bar menu with tools that allow to perform more detailed analysis is located on the right side of IR the IR image. (see 4.1.1).

The right side window under 'Picture' tab allows to add note to IR image, set importance and change its emissivity value. Apart from that it displays additional information about the selected IR image. There is also a possibility to preview a visual image (provided that the imager that was used to capture the image features visual image camera).

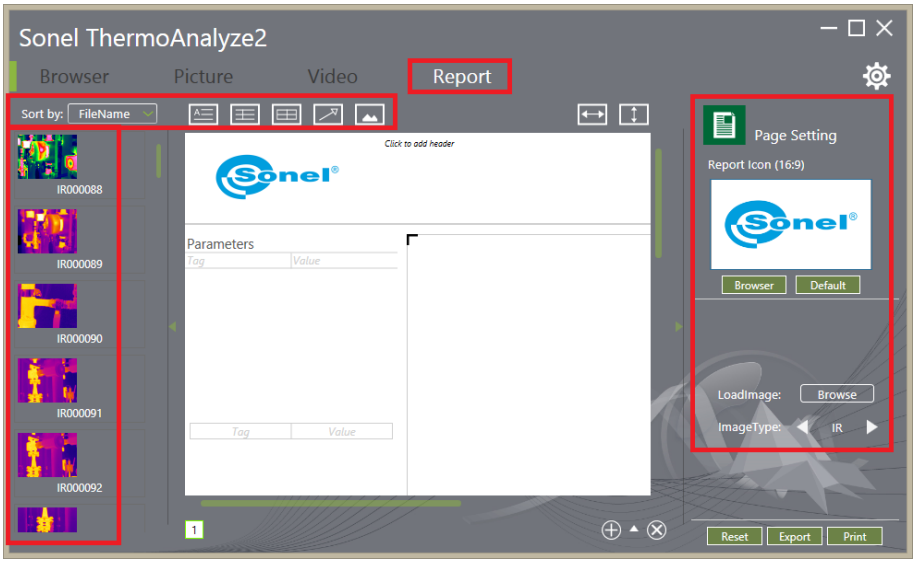
3.2.3 Video Tab



Tools available under **'Video'** tab allow to perform analysis of infrared video footage, recorded in on-line mode (for selected KT models), as well as the ones saved in the imager's memory. Temperature scale, with color bar representing different temperature levels, is located on the left side of the screen. IR camera connection status is located in the bottom, left corner of the screen (connected when on-line mode is selected). Icon menu bar is located on the right side of the screen, next to video window. It contains tools for editing and analyzing IR video. Window on the far right side of the screen allows, among others, selecting between two modes of operation: Real Time and Video:

It is possible to snap image from IR video footage at any time. This window also features icon menu with tools similar to the ones available under 'Picture' tab. go to 4.1.1. for details.

3.2.4 Report Tab



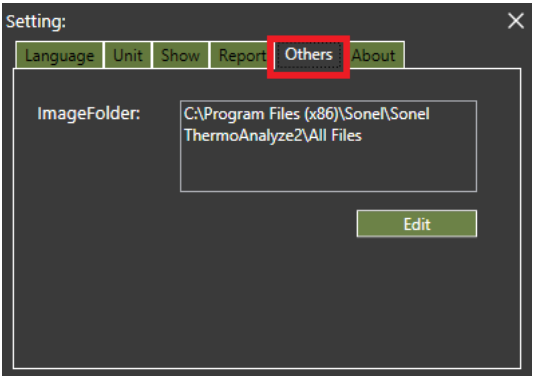
'Report' tab allows to create reports based on taken IR images. Thumbnails of the images that can be put in to the report are shown on the left side of the screen. Upper toolbar contains buttons that allow to add text, note, table and tag or image to the report. On the right side there is information about the selected object in the report. Selected object can also be modified here, for example, line or column in the report's table can be added.

4 Importing IR files to Sonel ThermoAnalyze2

There are three ways to import files into the program. Through Wi-Fi, USB or by copying files directly from SD card to PC's hard drive.

4.1 Importing IR files from SD card using system browser

When using SD cards, or, for imagers that are recognized as card readers in USB mode, IR files must be copied (removed) from SD card and pasted to the subfolder on a hard drive, that is located under directory set in 'Other' tab.

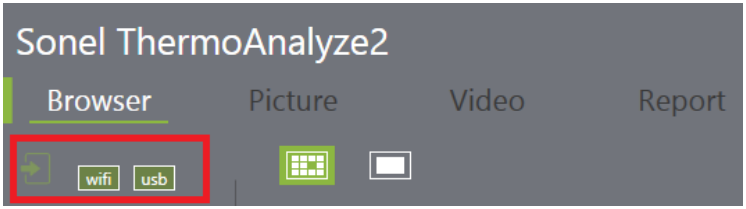


Copied files will be available on a list under 'Browser' tab.

4.2 Importing IR files from SD through Sonel ThermoAnalyze2 program.

USB cable, supplied with the imager, needs to be used to import files via USB (for selected KT models). Connected imager will be automatically detected (it doesn't apply to the cameras which are recognized as card readers when in USB mode).

Click  icon and 'USB' under 'Browser' tab, and import files.

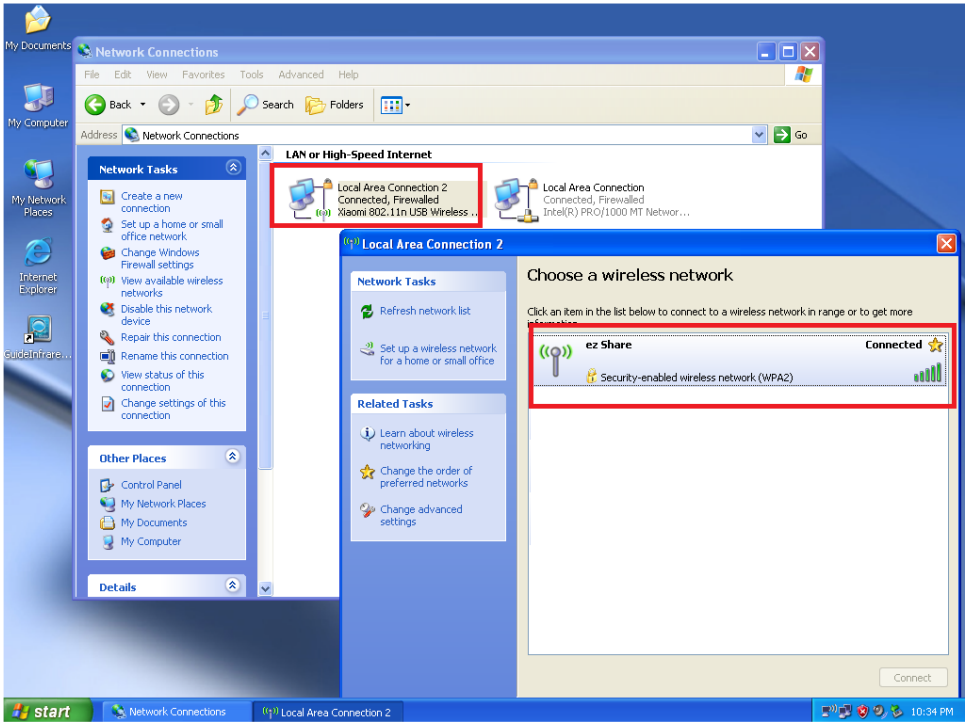


The program will display a list of all files stored on the SD card. It is possible to download selected images or all at once.

4.3 Importing IR files from SD via Wi-Fi

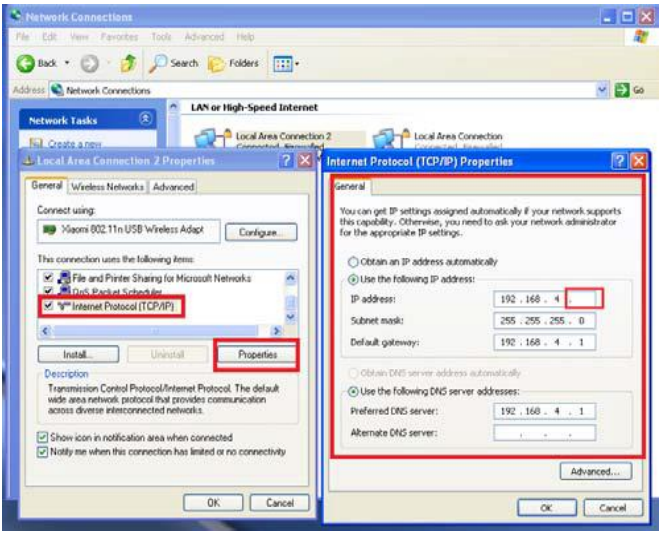
To connect to a camera via Wi-Fi, Wi-Fi SD memory card must be inserted inside imager.

Then, when connecting for the first time, connect to a wireless network called **'ez Share'**. It can be done in semi-automatic mode (recommended), by selecting above mentioned network from the list of available networks, and by clicking **'Connect'**. Default password to the network is: **88888888**.



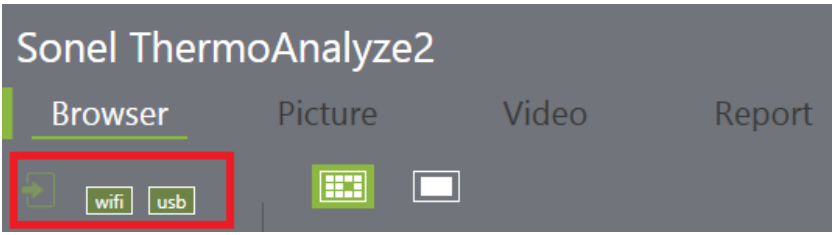
Network data and card settings will be set automatically.

In case of problems with connection (this method is for advanced PC users), IP address should be set manually. Connect to **ez Share** network, go to network card settings (Wi-Fi card) and type in following data: IP 192.168.4.（2-255), default gateway and DNS: 192.168.4.1, as shown below:



Save the settings (in most operating systems it's done automatically).

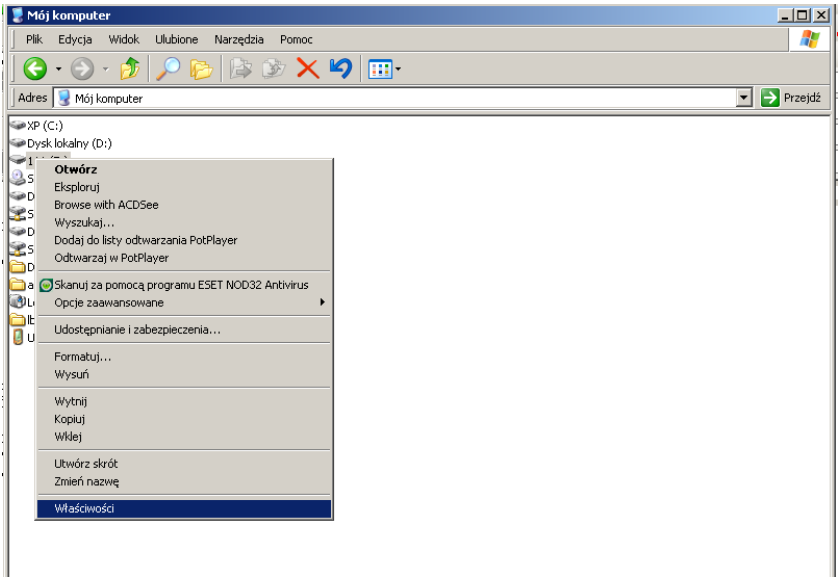
Once Wi-Fi connection is established, run Sonel ThermoAnalyze2 program. In order to connect with imager via Wi-Fi, go to **'Browser'** tab and click data import icon, and then click **wifi**.



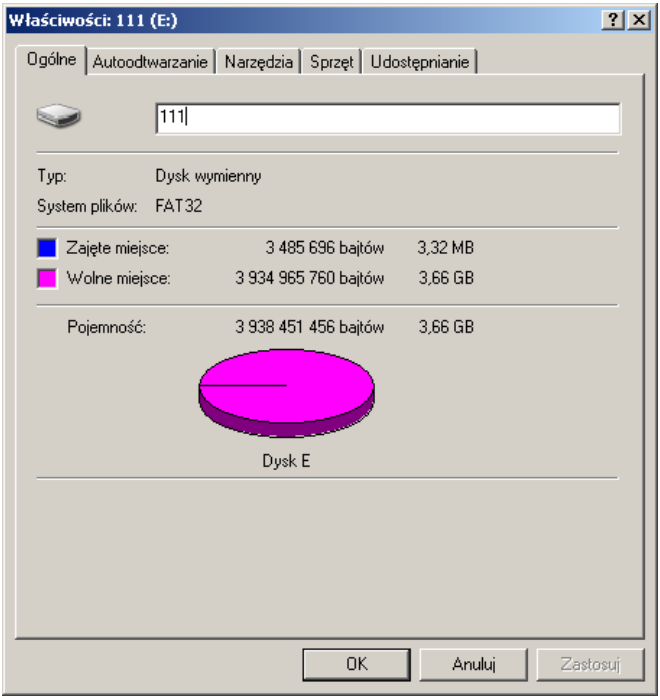
A list of files stored on the SD card will be displayed. It is possible to download selected images or all at once.

NOTE:

In case of any problems with detecting the SD Wi-Fi SD card in the camera, make sure that the card's name is "111". To do this, insert the card in your computer and right-click the card icon, then select "Properties":



The name field should state "111". If not, enter the correct name.

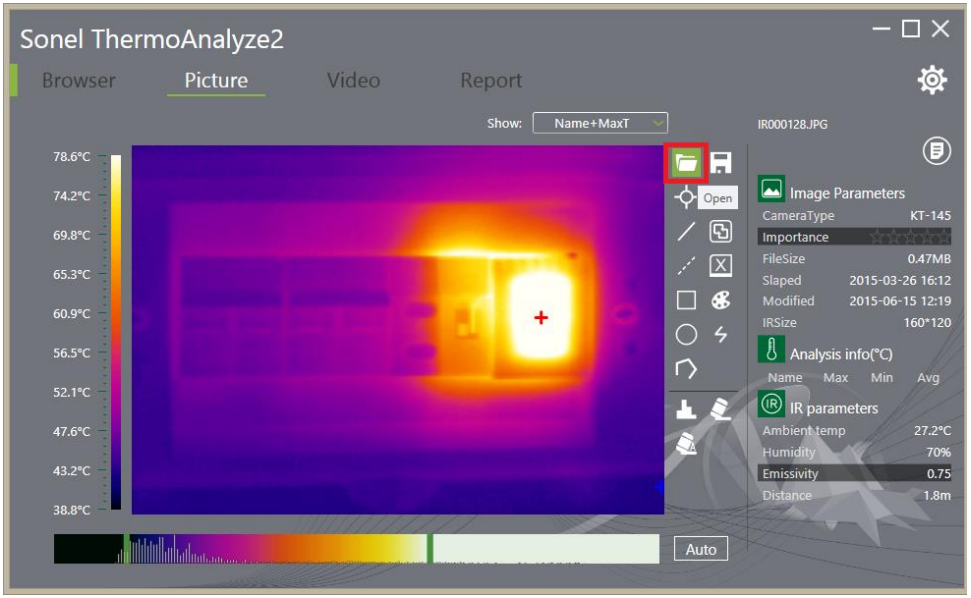


5 IR pictures analysis

5.1 IR pictures analysis

To start IR pictures analysis double click on selected picture under **'Browser'** tab. Chosen picture will be open in 'Picture' tab, where IR analysis is possible.

Alternatively, when in 'Picture' tab, click open folder icon in the upper right corner and select IR file to open.



5.1.1 Tools for IR images analysis and editing

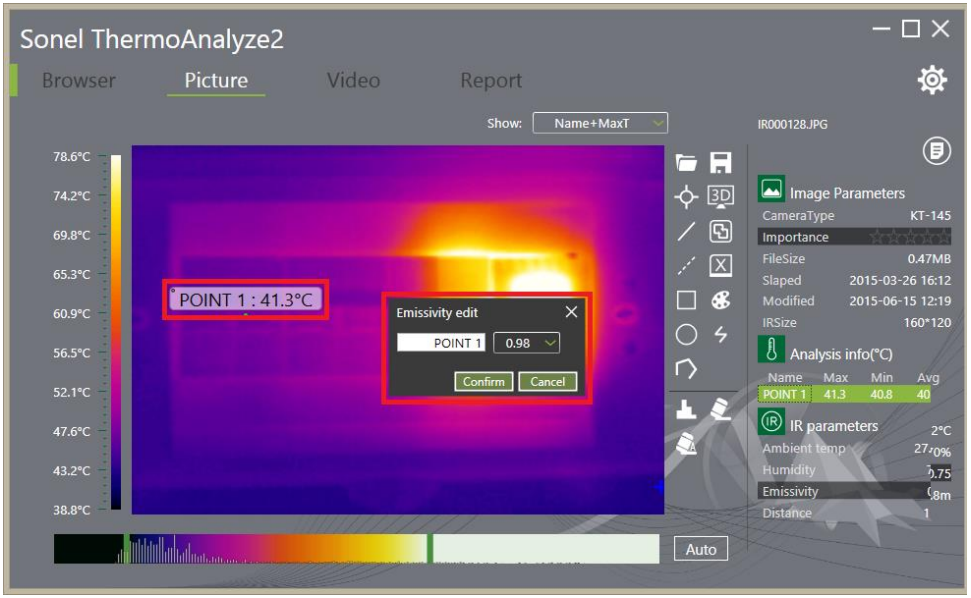
'Picture' tab allows to edit and analyze IR images. Measured temperature range, with corresponding colors, of selected IR image is presented on the left side of the window. This range is set automatically by the program based on the highest and the lowest measured temperature, however there is an option for adjusting the range manually.

There is an icon menu bar on the righr side of the 'Picture' tab window, that allows the following:

- Open, to open IR file from any location

- Choose ‘Spot’ command, to add up a spot that measures and shows temperature of the very pixel at which it sits over. This feature is also available in ‘Video’ tab.

To move the spot, move the mouse to the spot and the mouse pointer ill turn into a palm icon . Press and hold the left mouse button pressed and drag the spot to any place on the IR image. Double press left mouse button over the default name of the spot on the list, that is presented on the right side of the screen (under *Analysis info (°C)* tab), to change its name. New window will show up on screen, where the spot name and emissivity value can be edited.



- Choose ‘Line’ command, to add up a line to the IR image that shows the lowest, the highest and average temperature across the line. This feature is also available under **'Video'** tab.

To move the line, move the mouse to the line and the mouse pointer will turn into a palm icon . Press and hold the left mouse button pressed to move the line across the IR image. To move one end of the line (to change the size of the line), place the mouse cursor over one end of the line (marked as green dot), and the mouse pointer will turn into a four arrows cross icon . Keep the left mouse button pressed and drag the mouse to a desired place, then release the left button to confirm the new

place.

Double press the left mouse button over the default name of the line on the list, that is presented on the right side of the screen (under *Analysis info (°C)* tab), to change its name (see Spot name change).

- Choose ‘Delta’ command, to add a pair of spots to the IR image, for which the temperature difference will be measured on the fly. This feature is also available under **'Video'** tab.

To change position of the 'Delta', move the mouse to the ‘Delta’ and the mouse pointer will turn into a palm icon. Press and hold the left mouse button pressed to move the Delta across the IR image. To move the spots, between which the temperature difference is measured, place the mouse cursor over one end of the line (marked as green dot), and the mouse pointer will turn into a four arrows cross icon. While holding down the left mouse button, the position of the differential measurement spot can be freely changed.

Double press left mouse button over the default name of the line on the list, that is presented on the right side of the screen (under *Analysis info (°C)* tab), to change its name (see Spot name change).

- Choose ‘Rectangle’ (‘Rect’) command, to add a rectangle to the IR image. Within the area, covered by the created rectangle, the highest, the lowest and the average temperature will be presented. This feature is also available under **'Video'** tab.

To change position of the 'Rect', move the mouse to a line of the rectangle and the mouse pointer will turn into a palm icon. Press and hold the left mouse button pressed to move the selected rectangle across the IR image. To change the size of the rectangle, move the mouse pointer to any of the eight green dots that sit on the rectangle's outline. The mouse pointer will change from arrow into one of the following arrows icons: ⇔, ⇕, ⤡, ⤢ that point out the directions in which it is possible to change the rectangle's shape. While holding down the left mouse button, the shape of rectangle can be freely changed, in the directions designated by the arrows icons.

Double press left mouse button over the default name of the rectangle on the list, that is presented on the right side of the screen (under *Analysis info (°C)* tab), to change its name (see Spot name change).

- Choose ‘Circle’ command, to add a circle to the IR image. Within the area, covered by the created circle, the highest, the lowest and the average temperature will be presented. This feature is also available under 'Video' tab.

To change position of the 'Circle', move the mouse to a line of the circle and the mouse pointer will turn into a palm icon. Press and hold the left mouse button pressed to move the selected circle

across the IR image. To change the size of the rectangle, move the mouse pointer to any of the four green dots that sit on the circle's outline. The mouse pointer will change from arrow into one of the following arrows icons ⇔, ⇕, that point out the directions in which it is possible to change the circle's shape. While holding down the left mouse button, the shape of the circle can be freely changed, in the directions designated by the arrows icons.

Double press left mouse button over the default name of the circle on the list, that is presented on the right side of the screen (under Analysis info (°C) tab), to change its name (see Spot name change).

- Choose ‘Polygon’ command, to add a poligon to the IR image. Within the area, covered by the created polygon, the highest, the lowest and the average temperature will be presented. This feature is also available under 'Video' tab.

To change position of the 'Polygon', move the mouse to a line of the polygon and the mouse pointer will turn into a palm icon. Press and hold the left mouse button pressed to move the selected polygon across the IR image. To change the size of the polygon, move the mouse pointer to any of the green dots that sit on the polygon's outline (corners of polygon). The mouse pointer will change from arrow into a four arrows cross icon. While holding down the left mouse button, the position of the polygon's dots can be freely changed. To add another point in the polygon, double-click the left mouse button on the polygon's line, and the two dots of the selected line, between which another point can be added, will start flashing. To exit the point adding mode, single click the right mouse button at any place on the IR image.

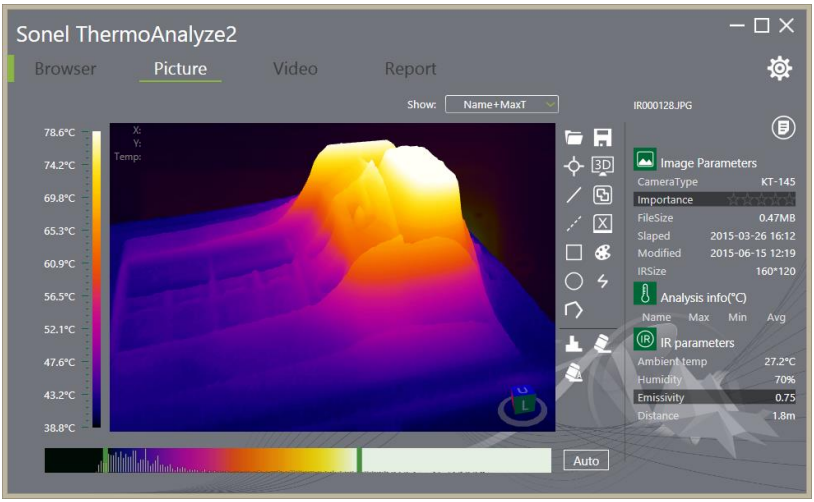
Double press left mouse button over the default name of the polygon on the list, that is presented on the right side of the screen (under Analysis info (°C) tab), to change its name (see Spot name change).

- Choose ‘Delete’ command, to delete the selected/active analysis item from the IR image. This feature is also available under 'Video' tab.

- Choose ‘DeleteAll’ command, to delete all analysis items from the IR image. This feature is also available under 'Video' tab.

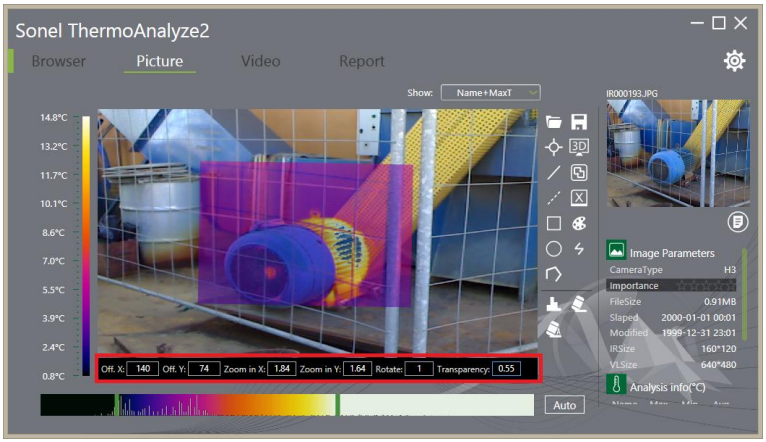
- Choose ‘Save’, to save the IR image, with all the changes applied to it during analysis.

- ‘3D Show’ mode allows to see IR image in 3D perspective. In many cases, a preview 3D image, that is generated based on the temperature distribution across the IR image, makes it very easy to pinpoint the exact fault location.



To zoom in or zoom out the 3D view, use the mouse wheel button. Move it up to zoom in the 3D image, and move it down to zoom out.
3 axis rotation of the 3D image is active when the right mouse button is pressed.

- 'IR Blending' command, allows to sets IR image and visual image in fusion. When visual image and IR image are linked, an additional bar that allows to adjust parameters of the IR image, will be displayed.



To move the IR image, that sits over visual image, press and hold the left mouse button, and then move the mouse in the desired direction.

To enlarge or shrink the IR image, select it by pressing the left mouse button and then move the

mouse wheel button up or down.

There are several small windows at the bar below the IR image, that allow to change the position of the IR image, turn it left or right, and they also allow to change the degree of transparency of IR image.

Off. X: Allows to move the IR image left or right. To move the IR image press the left mouse button within the window on the right side of the 'Off. X' line, and move the mouse wheel button up or down to move the IR image right or left.

Off. Y: Allows to move the IR image up or down. To move the IR image press the left mouse button within the window on the right side of the 'Off. Y' line, and move the mouse wheel button up or down to move the IR image up or down.

Zoom in X: Allows to zoom in (enlarge) the IR image horizontally. To zoom in or zoom out the IR image horizontally, press the left mouse button within the window on the right side of the 'Zoom in X' line, and move the mouse wheel button up or down to enlarge or shrink the IR image to the desired size.

Zoom in Y: Allows to zoom in (enlarge) the IR image vertically. To zoom in or zoom out the IR image vertically, press the left mouse button within the window on the right side of the 'Zoom in Y' line, and move the mouse wheel button up or down to enlarge or shrink the IR image to the desired size.

Rotate: Allows to rotate IR image left or right in relation to visual image. To rotate the IR image left or right, press the left mouse button within the window on the right side of the 'Rotate' line, and move the mouse wheel button up or down to rotate the IR image in the desired direction.

- Report command allows to go straight to the Report tab to develop an IR measurement report.

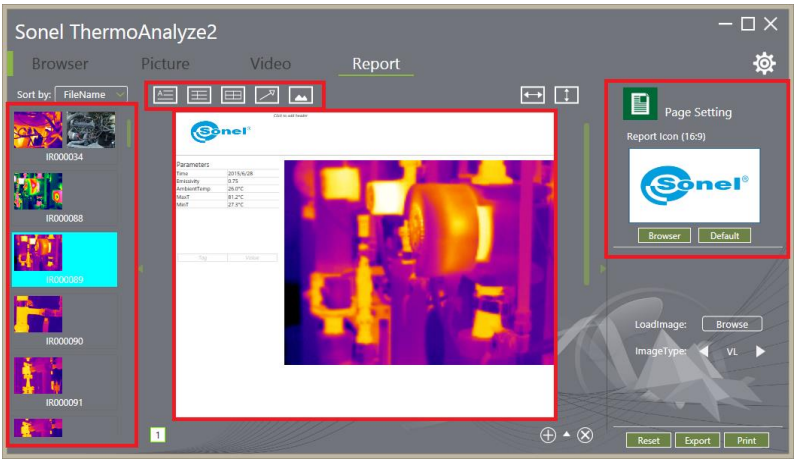
- Palette command displays 9 available color palettes. This feature is also available under 'Video' tab.

- Isotherm command, allows to add isotherm to the active IR image. The temperatures of selected range will be marked and displayed in additional, selected color.

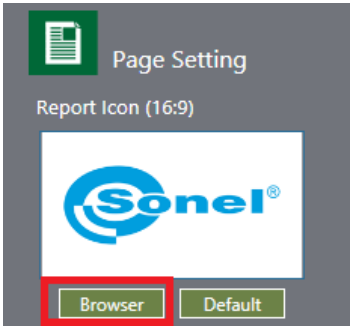
6 Creating Report

6.1 Creating report out of the taken IR images – general information.

In order to create a new report go to the ‘Report’ tab. Click the tab to open up the window as below.



A default logo used in the report is placed in the top right corner of the 'Report' window. To change the logo, press the 'Browser' button under the logo. This will open a window where a new logo can be selected.



Icons allowing to add or remove another report pages, along with a pointing up arrow, that allows to bring up the report templates window to the screen, are located in the bottom right corner of the 'Report' window. Template window allows to add edited report page as a template, that can be used in future reports, to speed up and facilitate the work.

 - ‘Add Page’ command, adds new page to the report.

- ‘Delete Page’, removes selected page from the report.

- Open Template Window, opens available templates. Newly created report can be added as a new template by clicking on an empty template field marked with a *plus* symbol. Any template can be removed by clicking on the *minus* in the bottom right corner of each template.

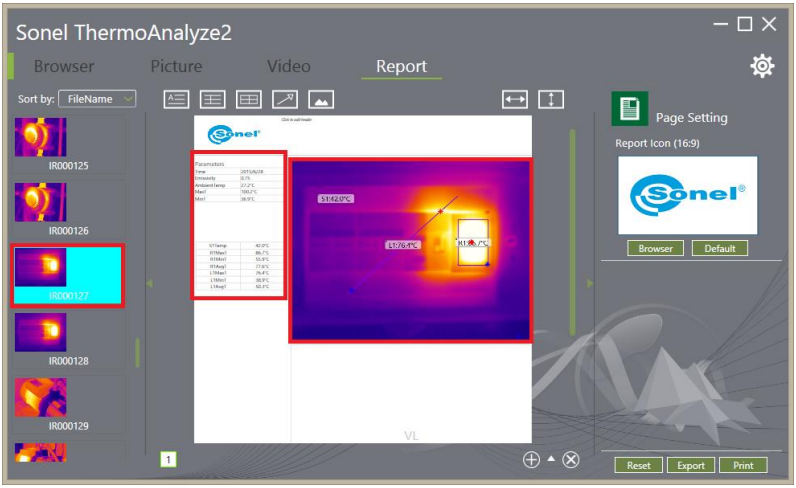
There are three buttons in the bottom right corner of the ‘Report’ tab.

‘Reset’ – Removes all the report pages that have been generated, and returns to the detault settinfs, but it keeps previously generated report templates.

‘Export’ – allows to save report in PDF file format in a file folder selected by user.

‘Print’ – allows to print out report.

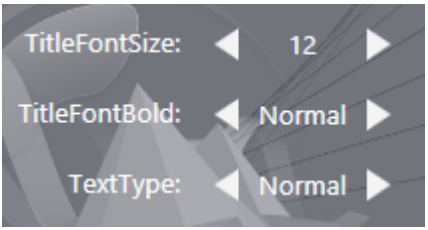
All IR images that can be used in the report are listed on the left side of the screen. To put selected IR image in the report double click the left mouse button on the IR image. The program will automatically put information about all the previously selected analysis items in a table, which is placed on the left side of the report.



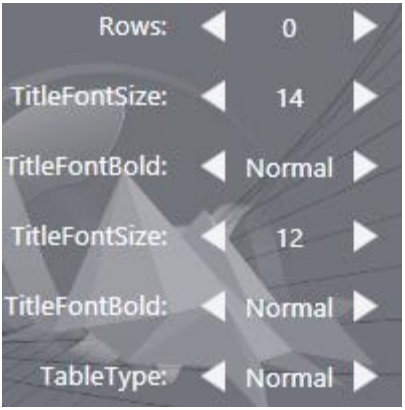
To add text in a report, click the left mouse button once at the place where you want to add text.

An icon menu, that allows to add objects to report, is located in the top left corner of the 'Report' window.

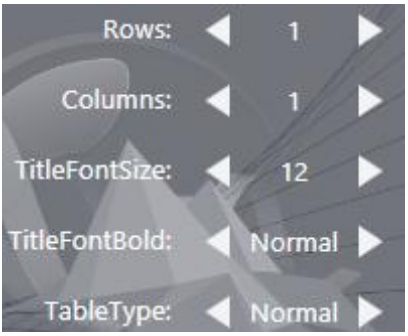
- Add Text, allows to add text box in the report. Its position and size is confirmed by pressing and holding the left mouse button. After selecting created text box, its adjustable parameters are displayed on the right side of the report.



- Add Annotation, allows to add annotation box in the report. Its position and size is confirmed by pressing and holding the left mouse button. After selecting created annotation box, its adjustable parameters are displayed on the right side of the report. .



- Add Table, allows to add a table in the report. Its position and size is confirmed by pressing and holding the left mouse button. After selecting created table, its adjustable parameters are displayed on the right side of the report.



- Add Tag allows to place a marker, which allows precise indication of the place, on the IR image, described in a table, note or a text box. When the tab is added in the report, its end and its beginning can be freely moved across the report. To do so, click the left mouse button on the tab. A small circles will appear at the end and at the beginning of the tab. Move the mouse pointer to one of the circles and press and hold the left mouse button to move it.

7 Emissivity

What is emissivity?

The concept of emissivity is inextricably linked with the physical model of a black body. It is a term used in physics, determining the object absorbing the whole electromagnetic radiation it's exposed to, whatever the temperature of the body, the angle of incidence and spectrum of the incident radiation. The absorption coefficient for such a body is equal to one for any wavelength.

For the blackbody model we take an enclosure with irregular interior, covered with soot, with only one small hole leading inside. The radiation coming inside by this hole is reflected many times by the walls, which results in the entire radiation being absorbed. Thus, the parameters of the radiation coming out from the inside of a black body depend only on the temperature of its interior.

A small hole in such an enclosure only affects this radiation level very slightly. The area of the hole should not exceed 5% of the area of the walls of the enclosure, when the radiation passing through the hole is within about one part in a thousand of the blackbody radiation level defined by the wall temperature.

A real object's surface always emits less radiation than a black body of the same temperature would. Radiation emitted by surface to Radiation emitted by black body ratio is called emissivity.

$$\text{Emissivity} = \frac{\text{Radiation emitted by surface with specified temperature}}{\text{Radiation emitted by black body with the same temperature}}$$

How to deal with emissivity?

If you read the temperature ignoring the phenomenon of emissivity, the read temperature will be lower than the actual temperature. This temperature is known as the "apparent" or "brightness" temperature of the surface. If the emissivity is constant, this temperature rises and falls in exactly the same way as the true temperature.

Because we are interested in getting to know the real temperature, we have:

$$\text{Actual output} = \varepsilon \times \text{output when measuring blackbody}$$

To obtain the true surface temperature we must divide the actual output by the emissivity value ε before we convert to temperature.

It is therefore necessary to know the value of the emissivity of the measured surfaces. There is a vast amount of data available; unfortunately much of it is confusing because substantially different values are quoted. This is because emissivity depends upon:

- Surface condition - roughness and oxidation

- **Temperature (also ambient temperature)**

- Angle of view

- Infrared Wavelength

For materials with smooth, clean (unoxidised) surfaces, emissivities are usually in the range of 0.05 to 0.50 and are usually very wavelength dependent, being higher at shorter wavelengths. The appropriate settings for the KT Thermal Camera are given in the following table. It must be remembered that these are only guideline figures. They can be substantially increased if the surface is rough or even slightly oxidised. The values quoted for oxidised metals assume that the metal is heavily oxidised. Thin oxide layers will give an emissivity value between this and the value for an unoxidised surface.

Adjusting emissivity value for the object or the whole thermal image, you need to take **real ambient temperature** value into consideration when performing measurements.

aluminum.....0.05
aluminum Rough.....0,07
Aluminum oxidized.....0,25
asphalt.....0,90
asbestos board 0,96
asbestos (fiber).....0,78
akelite.....0,93
bronze: dull 0,22
bronze: polished..... 0,10
bronze: rough 0,55
brick: glass., rough..... 0,85
brick: fireproof, rough..... 0,94
cement..... 0,54
cement (concrete)..... 0,90
chrome.....0,15
chrome polished..... 0,10
tin.....0,09
zinc.....0,05
brick red.....0,93
paint: oil.....0,94
clay: fired.....0,91
clay.....0,40
graphite..... 0,85
ground: frozen..... 0,93
rubber.....0,93
cobalt..... 0,18
quartz.....0,93
lacquer white..... 0,87
lacquer polished black..... 0,87
lacquer dull black..... 0,97
lacquer silver..... 0,31
ice..... 0,97
magnesium.....0,12
copper: oxidized..... 0,65
copper: oxidized black..... 0,88
copper: polished..... 0,07
copper: polished annealed.....0,01.. 0,02
brass..... 0,10
brass: oxidized..... 0,61
nickel : polished..... 0,05
lead: polished..... 0,08
lead: grey..... 0,28
lead: oxidized.....0,63
paper white..... 0,90
paper black glossy..... 0,90
paper black dull..... 0,94
paper: tarred..... 0,92
plastic: black..... 0,95
platinum..... 0,10
porcelain: glazed..... 0,92
mercury..... 0,10
lampblack..... 0,96
silver..... 0,03
steel: galvanized..... 0,28
steel: oxidized..... 0,88
steel: rolled freshly..... 0,24
steel: rolled..... 0,56
steel: rough..... 0,96
steel: rusty red..... 0,69
steel nickeled..... 0,11
glaze..... 0,90
glass..... 0,92
glass dull..... 0,96
snow..... 0,80
tape insulation..... 0,95
fabric..... 0,85
titanium..... 0,30
carbon..... 0,90
charcoal powder..... 0,96
tungsten..... 0,13
tungsten: oxidized..... 0,11
gold..... 0,02
iron: glossy..... 0,16
iron: heat rolled..... 0,77
iron: oxidized..... 0,74
iron: polished..... 0,23
iron and steel: oxidized..... 0,85
cast: raw casting..... 0,81
cast: polished..... 0,21