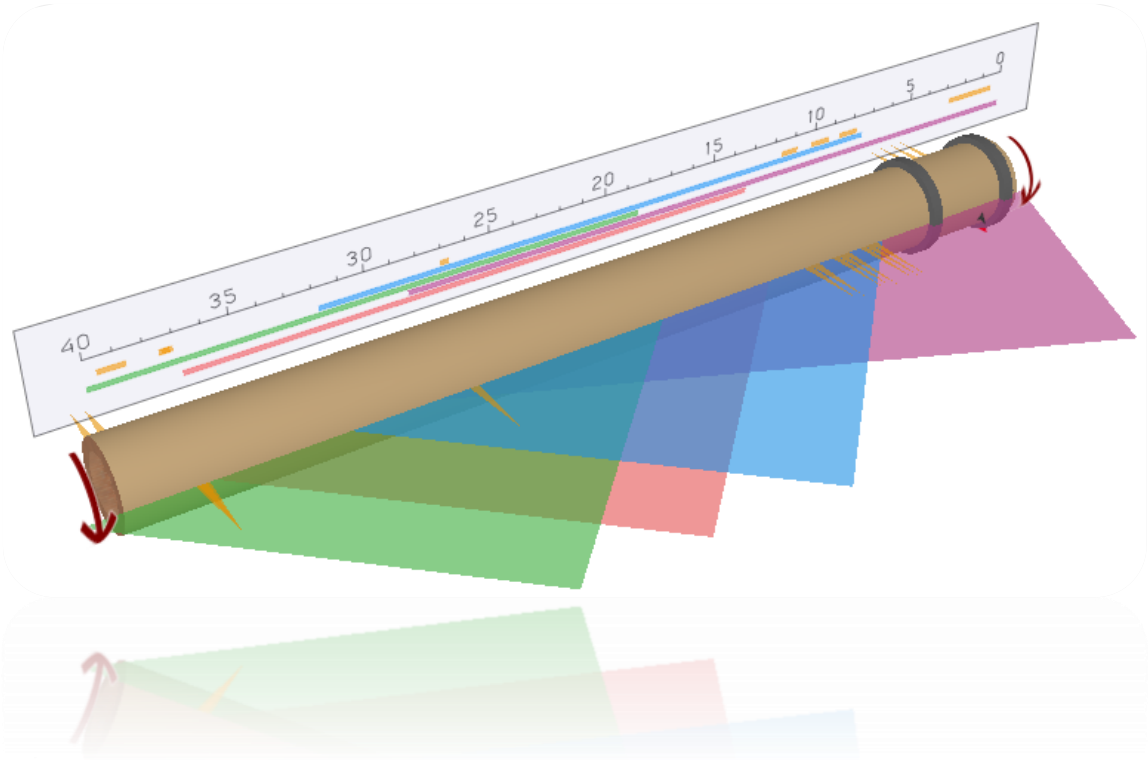
CS400

Kiln monitoring system



User's Manual

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This manual is available in different languages. In case of differences between the language versions, the English manual is binding.

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Table of Contents

Chapter **Page**

TABLE OF CONTENTS **3**

CONTACTS **5**

1. INSTALLATION AND GENERAL SETTINGS **6**

1.1. Description 6
1.2. PC requirements 6
1.3. License agreement 7
1.4. Software installation 7
1.5. Managing licenses 11
1.6. Start-up screen 15
1.7. Language and other program settings 17

2. CONFIGURATION **19**

2.1. Kiln monitoring principles 19
2.2. System configuration 19
2.3. Kilns monitored on one computer 21
2.4. Managing configurations 21
2.5. Importing CS200/CS210 configuration 22
2.6. Kiln dimensions and monitoring hardware 23
2.7. Scanner configuration 29
2.8. MP-scanner communication and parameters 33
2.9. Camera2D communication and parameters 35
2.10. ThermoView TV40 36
2.11. Pyrometer configuration 40
2.12. Pyrometer communication and parameters 41
2.13. WAGO 750-362 field bus coupler 44
2.14. Kiln shell image composition algorithm 48
2.15. The kiln trigger 49
2.16. Tire slip monitoring 52
2.17. Burning zone monitoring 55
2.18. Kiln refractory and special zones 56
2.19. Alarms 59
2.20. History storage 65
2.21. System backup and recovery 68
2.22. OPC UA configuration 71

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2.23. OPC Classic configuration ... 71
2.24. Passwords ... 74

3. OPERATION ... 77

3.1. Client-server structure ... 77
3.2. Connecting a client to a server ... 78
3.3. Starting and stopping kiln monitoring ... 79
3.4. Monitoring window ... 80
3.5. System state window ... 82
3.6. Alarms indication ... 86
3.7. Kiln views ... 87
3.8. Temperature map 2D view ... 88
3.9. 3D kiln views ... 92
3.10. Temperature scale and palette ... 96
3.11. Reference views ... 97
3.12. Horizontal profile ... 98
3.13. Temperature trend ... 99
3.14. Image trend ... 101
3.15. History reference ... 102
3.16. Refractory diagram ... 104
3.17. Thickness / Coating diagram ... 105
3.18. Tire slip indication ... 106
3.19. Rotation / Tire slip history ... 107
3.20. Burning zone ... 108
3.21. Resetting maintenance alarm ... 111
3.22. Monitoring window layouts ... 112
3.23. Multiple monitoring windows ... 112
3.24. Alarms suppression ... 113
3.25. Brick and coating thickness calculation method ... 114
3.26. Temperature inside the kiln ... 116
3.27. Resetting brick thickness map ... 117
3.28. Kiln history ... 117
3.29. Access to measured data for thrid-party applications ... 121
3.30. Logs ... 127

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1. Installation and general settings

1.1. Description

CS400 is a comprehensive temperature measurement system for the monitoring, control, and analysis of rotating kiln shells used in cement and lime production, mineral processing, hazardous waste incineration and other processes. This system is a unique combination of hardware centered on the industry-leading MP150 linescanner and a powerful, industrial software package. The system allows accurate monitoring of the kiln shell and early detection of hot spots indicating damaged or missing refractory bricks, preventing costly kiln damage and extending production runs.

The key component of the CS400 system is one or more infrared linescanners. The linescanner collects infrared energy, emitted from the kiln surface allowing the system to measure the temperature along the length of the kiln.

The CS400 system provides many features, which include full-color thermograms of the kiln surface, user defined alarms, automatic fan control and extensive historical data analysis capability. The CS400 system also adds OPC server functionality and full integration of all available accessories. Most notably, additional point sensors can be installed and configured to monitor portions of the kiln "shadowed" from the main sensor by physical obstructions and the results displayed as one homogenous thermogram. Similarly, a separate sensor is available to monitor the burning zone of the kiln and again the data will be seamlessly incorporated into one common display in the control room.

Using a optical fiber cable from the scanner in the field to the PC Ethernet interface in the control room is a reliable way for connecting. Using fiber optics, you can prevent electrical interference from corrupting the CS400 system. The optical fiber cable supports high speeds and long distance transmissions (up to 2 km / 1.2 mi). One fiber optic communication line only from the field to the control room minimizes the installation efforts on-site.

1.2. PC requirements

Software

CS400 has been designed to work with Microsoft Windows 7/8/10 32 and 64 bit operation systems (ARM architecture is not supported).

Hardware

PC hardware requirements depend on the number of monitored kilns and the number of used scanners. For servers it is also important to consider how many clients should be served simultaneously. For most cases this configuration will be sufficient:

- Processor: x64 architecture, two-core with 3 GHz per core or four-core with 2 GHz per core
- RAM: 4 GB

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- Hard disk: at least 500 GB free space (for history database), 7200 RPM HDD or better an SSD
- Display: 1920x1080 or higher resolution with about 96 DPI (high density monitors are not supported).
- Gigabit Ethernet LAN adapter

1.3. License agreement

IMPORTANT NOTICE

Read this License Agreement carefully before using this Software. BY USING THIS SOFTWARE IN ANY WAY YOU ACKNOWLEDGE THAT YOU HAVE READ, UNDERSTAND AND AGREE TO THE TERMS OF THIS AGREEMENT. IF YOU DO NOT AGREE TO THESE TERMS, DO NOT USE THIS SOFTWARE IN ANY WAY, AND PROMPTLY RETURN IT OR DELETE ANY COPIES OF THIS SOFTWARE IN YOUR POSSESSION.

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1.4. Software installation

Important

Administrator privileges are required to install CS400 and associated drivers. If you install CS400 on a computer managed by an IT department, please contact your System Administrator for assistance.

After installation and configuration, CS400 can be used as a normal user, a*dministrator privileges* are not required.

Installation procedure

You will receive CS400 installation file on a flash drive or as an Internet download in form of EXE installation file. To install the software on a computer, run the installation file (double click on it in Windows Explorer) an follow the instructions on the screen.

After installation completed, CS400 will be started for the first time and you will need to enter the *Installation Key* from the license that you receive together with the installation file. Please see Managing licenses for details.

Firewalls

During installation CS400 automatically adds itself to the Windows Firewall exceptions list. Steps below are required only if you have problems connecting to the hardware (scanners) or there are problems accessing data by CS400 clients.

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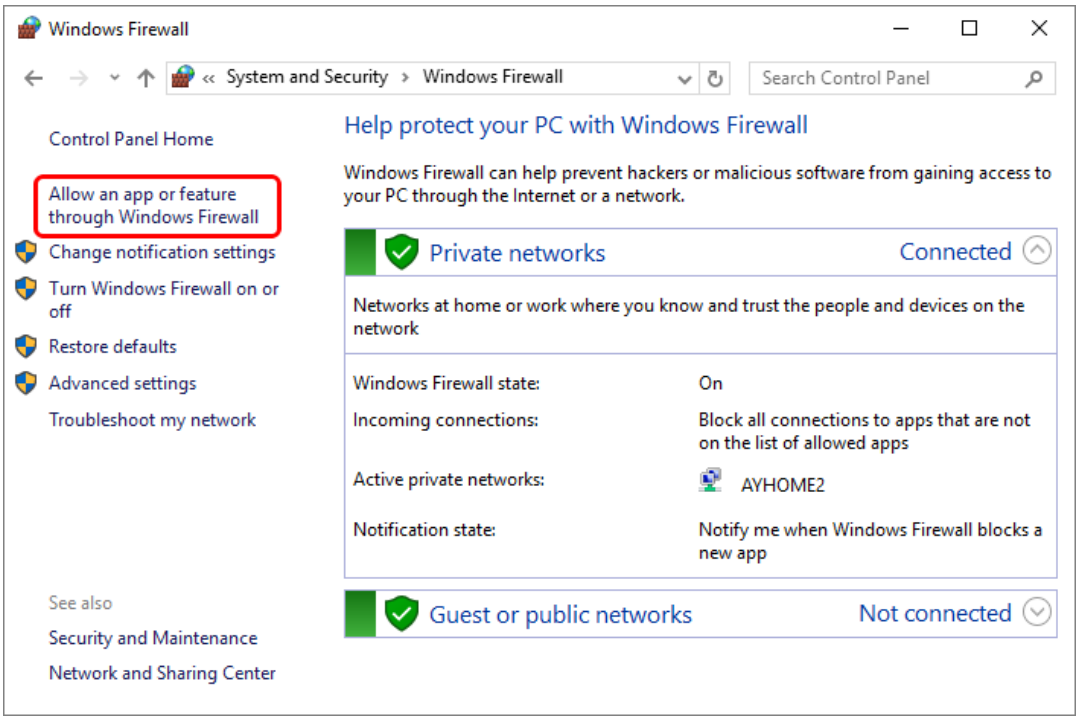
Manual firewall configuration

Firewalls will generally block network connectivity. To restore the connectivity you need to change configuration of the firewall. We will discuss Window Firewall as it is delivered with every Windows installation. If you use another firewall, please consult its documentation.

CS400 is automatically added to the exceptions list in Windows Firewall during the first start at the end of installation procedure. If automatic configuration did not work out, please configure Windows Firewall manually as described below.

To allow CS400 to receive data on the network you need to add CS400 to the exceptions list (list of programs allowed to send data to the network) in Windows Firewall:

1. Open the Control Panel (icons view), and click/tap on the Windows Firewall icon.
2. Click/tap on the 'Allow a program through Windows Firewall link' in the left pane.



3. Choosing the option to allow a program through the firewall will present you with a list of current exceptions. If the 'Allow another app…' button is disabled then you will need to click the 'Change settings' button. If your computer is controlled by an IT department you may not have permission to change these settings and you will have to get your IT administrator involved.

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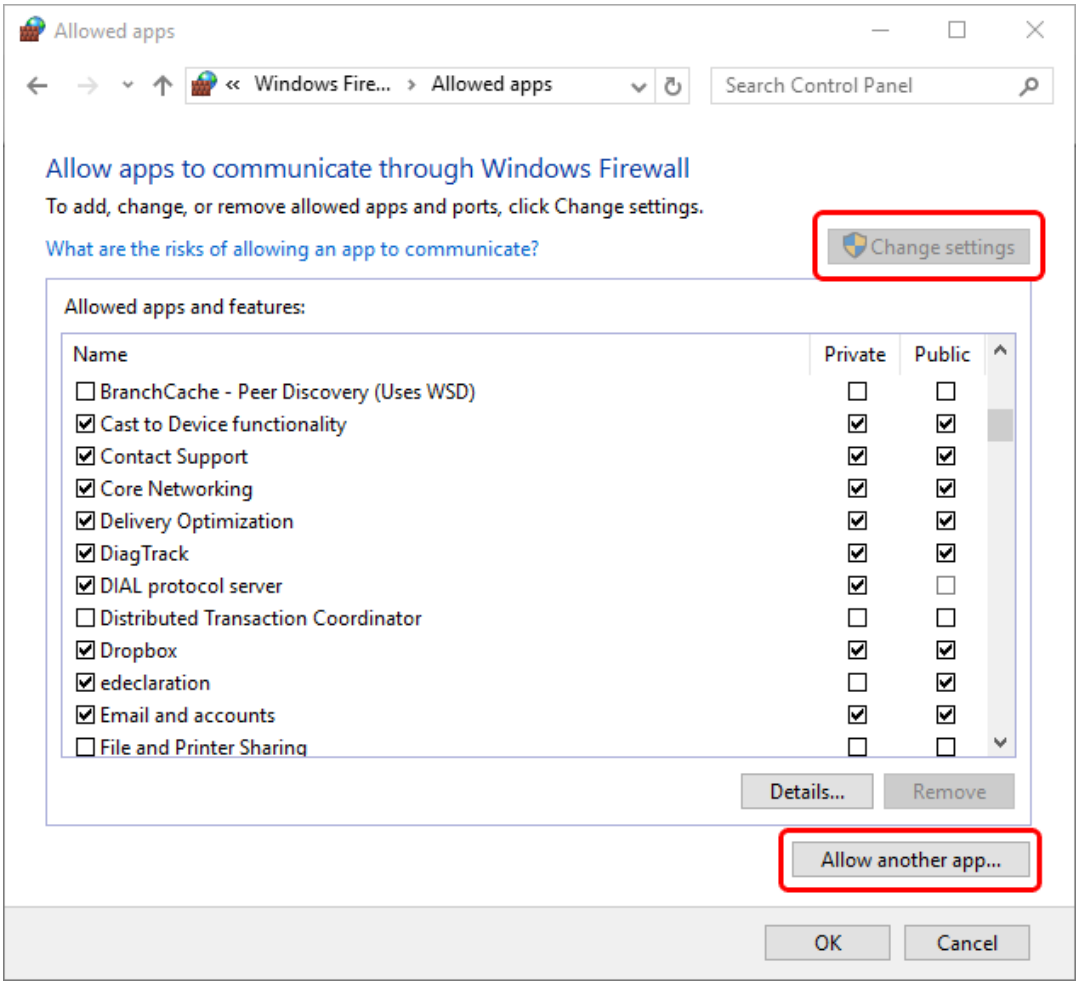

4. Then you will see the 'Add an app' dialog

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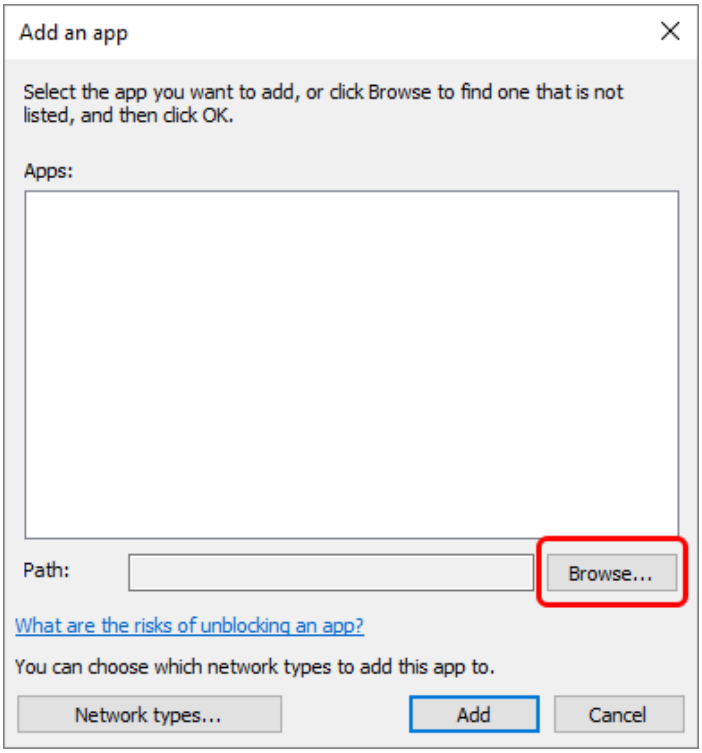

5. Click the 'Browse...' button. Go to the place on your hard drive where CS400 is installed. Select Linescano.exe.

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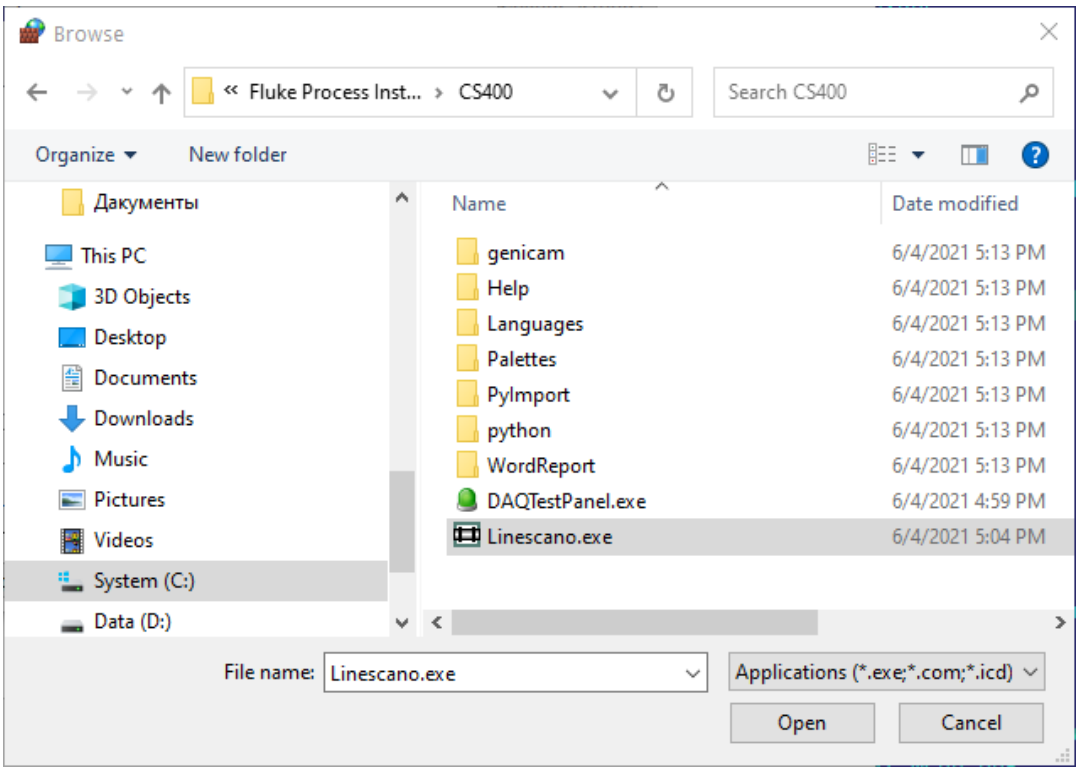

6. Enable all the check boxes for Private/Public/Domain.

Removing CS400

You can remove CS400 from your computer by using the Microsoft Windows uninstall program procedure (Start > Control Panel > Programs > Programs and Features).

1.5. Managing licenses

CS400 incorporates cloud based licensing system to prevent unauthorized use of the software. With your copy of software you will get so called *Installation Key*, a text string in form:

WPXXXX-XXXXXX-XXXXXX-XXXXXX-XXXXXX-XXXXXX-XXXXXX.

This key represents your license and links your copy of software with our licensing database. With one *Installation Key* you can install software on one PC or several PCs. This depends on the license that you have purchased.

There are also trial installation keys available that allow to use CS400 with all its functions for a limited period of time.

First run

After installation CS400 will be launched for the first time and you will need to enter the *Installation Key*, your name and name of the organization purchased license belongs to.

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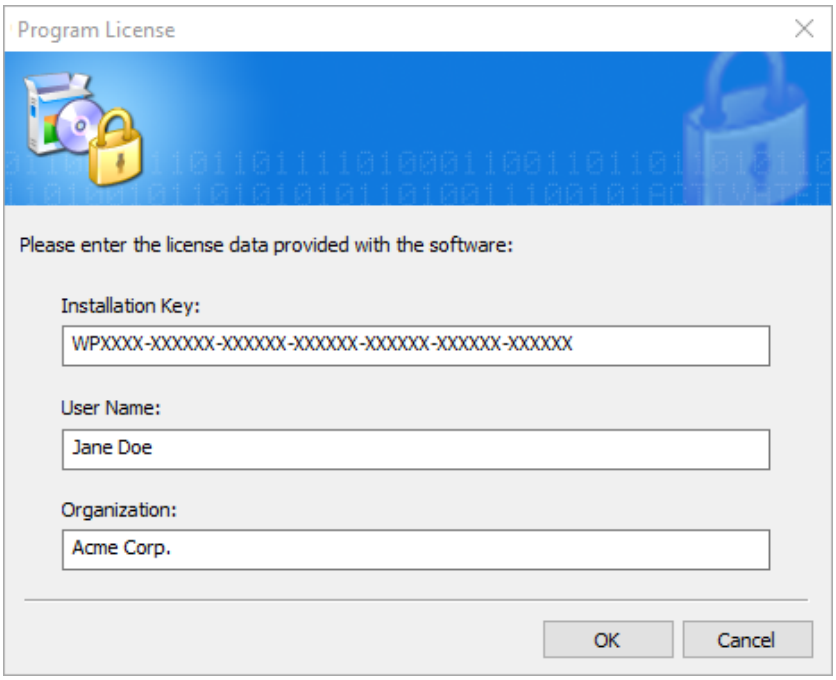
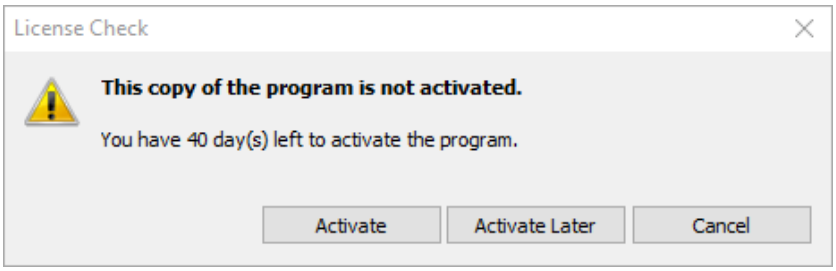


Activation

Before you can use the software you need to connect to our licensing server and activate the program.



If you have Internet connection, select "Activate by using the Internet".

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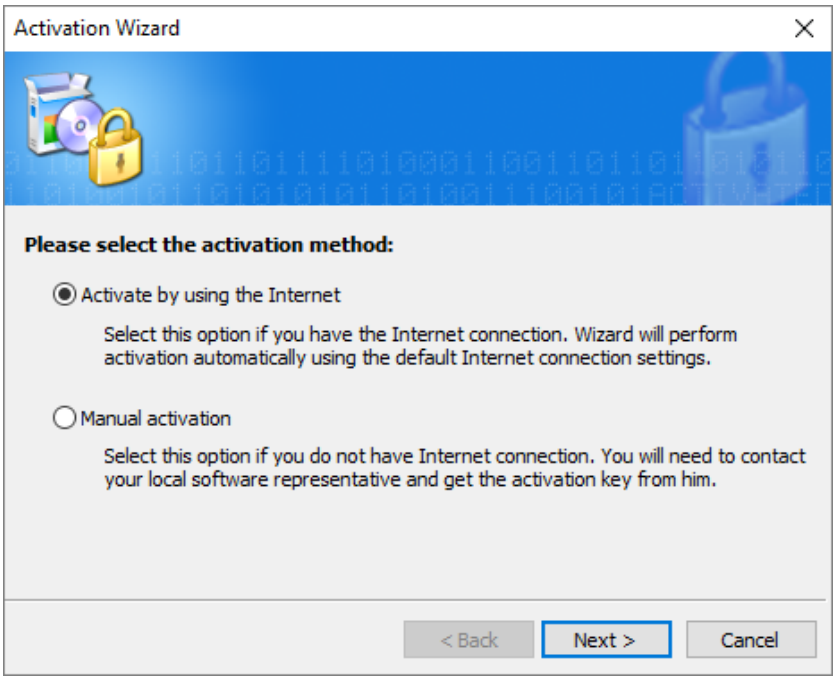

CS400 will connect to the activation server and activate your copy of the program.

Manual activation

If your PC is not connected to the Internet, you need to select 'Manual activation' option. This procedure is not automatic and you will need to contact Fluke Process Instruments by e-mail: softwaresupport@flukeprocessinstruments.com.

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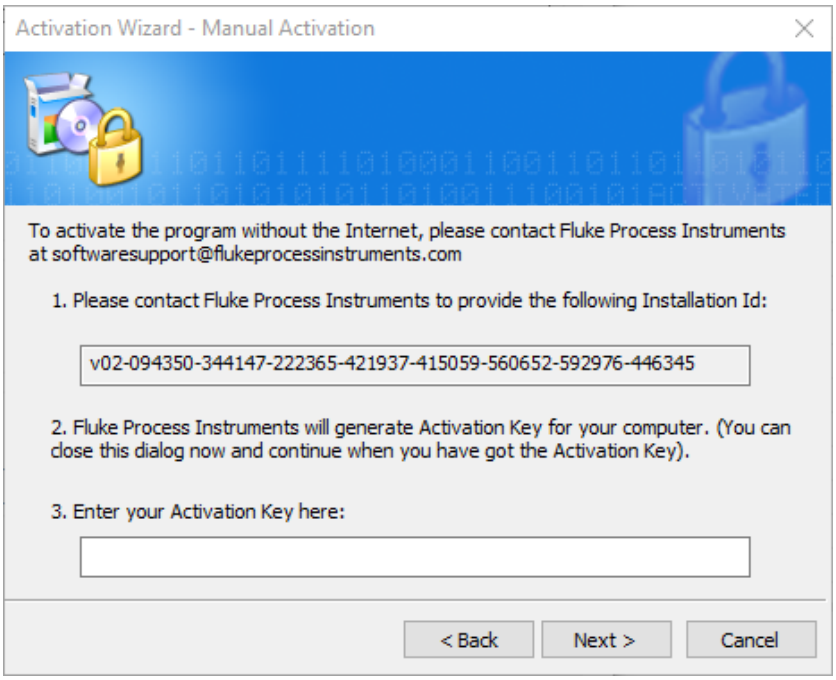

Please pass the *Installation Id* to Fluke Process Instruments (softwaresupport@flukeprocessinstruments.com). *Installation Id* is a unique signature of your PC that will be linked to your license. It is used to generate *Activation Key* that activates your copy of the software.

At this point you can close Activation Wizard. When you will get *Activation Key*, please run Activation Wizard again (you will need to close and open CS400) and type or copy *Activation Key* to the corresponding edit box. Click 'Next' to finalize the activation.

Transferring license to another PC

If you stop using CS400 on a PC you can transfer your license from this PC to another computer. For this you need to deactivate the license on the old PC. After that your license (*Installation Key*) can be used to install CS400 on any other PC.

Select 'Help | Deactivate License' in the main menu.

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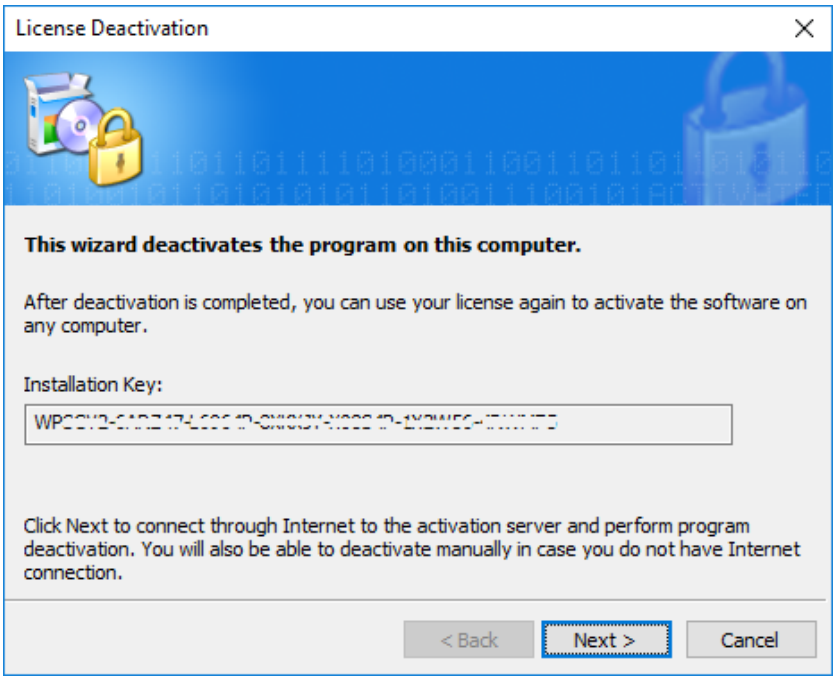

Click 'Next' to deactivate the software automatically through the Internet. In case your computer is not connected to the Internet, you will be given the possibility to deactivate manually with help of your software provider. Procedure is very similar to the manual activation described above.

1.6. Start-up screen

When you start CS400 the start-up screen is shown with the selection of options to continue:

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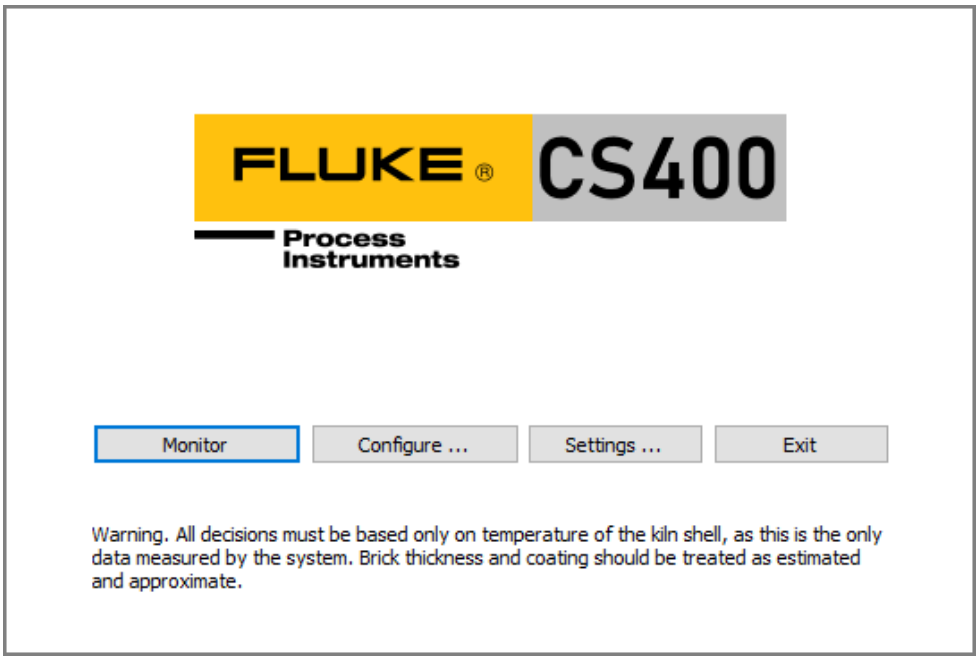

- Press **Monitor** to start monitoring all kilns and to see and analyze the current results of kiln monitoring. You should do it after kilns configuration and program settings are adjusted. Program will switch to the Monitoring window.
- Press **Configure** to create or change kilns configuration. See System configuration for details.
- On CS400 Clients press **Connect** button (shown instead of Configure) to select CS400 server which will provide monitoring data.
- Press **Settings** to adjust program settings - language, passwords, date format, temperature and linear units, etc. See Language and other program settings for details.
- Press **Exit** to stop all kilns monitoring and close the application.

The start-up screen also shows the current state of kiln monitoring – the table under the main menu, each line corresponds to the monitored kiln.

First Kiln	Stopped	ALARM	
Second Kiln	Stopped	Error	
Third Kiln	Stopped	Outdated	

Double click on a kiln line to open its System State window.

When the start-up screen is displayed, the following menu commands are available:

System menu

- **Change Passwords** opens Passwords dialog to set or change access passwords.
- **Program Settings** opens program settings. See Language and other program settings for details.
- **Configurations** opens dialog to create new or change active system configuration.

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- **Restore Configuration**, **Restore History** restores system configuration and kiln history from a backup.
- **Configure Kilns** sets up or changes kilns configuration (same as the **Configure** button).
- **Export Configuration** saves active system configuration in a file and then import this file on a different PC
- **Exit** quits the application.

Monitoring menu

- **Open Monitoring Window** opens window that displays current results of kiln monitoring (same as the **Monitor** button, but without starting monitoring).
- **Start (Stop) Monitoring All Kilns** starts or stops monitoring of kilns configured on this computer.
- **Remotely Monitored Kilns** displays the dialog to connect to the kiln monitoring server over the network (this menu item is available only in Clients).

View menu

- **View / Log Files** opens the folder with log files containing detailed information about events and alarms for each kiln (in text files).
- **View / Program Settings** displays program settings (same as the **Settings** button).
-

> **Hint**
>
> Every time you close all monitoring windows and the configuration window you return to the start-up screen. This does not stop kilns monitoring. Monitoring continues in the background with data gathered, processed, checked for alarms and stored.

1.7. Language and other program settings

To display the Settings dialog, on the start-up screen press **Settings** button or choose **System / Program Settings** in the main menu.

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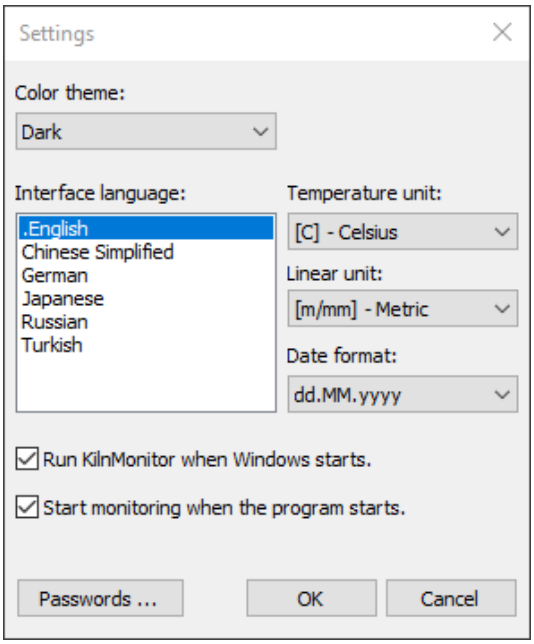

Here you can modify the following settings:

Color theme: *Windows default* or *Dark*. Dark theme is supported in Windows 10 and later. Only monitoring windows will use dark mode, configuration windows are always displayed with Windows default theme.

Temperature unit: *Celsius*, *Kelvin* or *Fahrenheit*.

Linear unit: *Metric (m/mm)*, *Imperial (ft/inch)* or *Centimeters (cm/cm)* measure of lengths. Large lengths, like the kiln length or a scanner distance are displayed using the first unit in the brackets; small lengths, like tire slip or brick thickness are displayed using the second unit.

Date format: *dd.MM.yyyy*; *MM/dd/yyyy*; *yyyy-MM-dd*.

Passwords allows to limit access to different functions of the program with passwords.

Run CS400 when Windows starts: if selected this option instructs Windows to automatically start the application when Windows is started (after the user is logged in).

Start monitoring when program starts: automatically switch to the monitoring window and start monitoring of all kilns when program is restarted. If this option is not enabled, kiln monitoring will not start when program starts and the operator will need to start kiln monitoring manually.

> **Note**
> Changes in the regional settings will be applied only after the program restart.

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2. Configuration

2.1. Kiln monitoring principles

As the kiln rotates the thermal scanner records temperatures at each point of the kiln body. After each complete revolution, the data is analyzed and a temperature map of the entire kiln surface (thermal image) is generated. Knowing the temperature inside and on the surface of the kiln and using the thermal conductivity formula it is possible to estimate the thickness of the bricks as well as the thickness of the stuck clinker material ("*coating*").

Often one scanner is not enough to cover the whole surface of the kiln. In this case additional scanners are used. Also, depending on the kiln design and the room where the kiln is located (supporting rings, pillars etc.), parts of the kiln can be inaccessible to the scanners. Such areas are called "*shadow zones*". Pyrometers are used to monitor the temperatures of these areas. Data from all scanners and pyrometers are gathered together to form one composite map of the kiln surface condition.

To find out when the kiln made a complete revolution and the temperature map can be build CS400 needs a signal from the outside. A sensor that sends a signal after each complete revolution must be connected to the system. The signal is called "*kiln-trigger*". A complete revolution of the kiln is called a "*lap*".

Laps

After each full revolution (lap) CS400 system executes the following operations:

1. Kiln shell temperature map is constructed from temperature data received from scanners and pyrometers.
2. Envelope profile is constructed from the kiln shell temperature map.
3. Alarm zones are checked for alarm conditions, hardware outputs assigned to alarm zones are updated.
4. Envelope profile is checked for alarms, corresponding hardware outputs are updated.
5. Kiln shell image with information about alarms and measurements is saved to the history storage.
6. New kiln state data is sent to clients connected remotely.

2.2. System configuration

Kilns can be configured only on the server PC. Configuration is not possible in CS400 clients where kiln data is received from the server remotely through the network.

To open the configuration dialog, press **Configure** button on the start-up screen or select **Configuration / Configure Kilns** in the main menu.

System configuration includes configuration of one or more kilns. Every kiln configuration has Installation, Refractory, Alarms and History parts. There is also configuration area that contains settings common for all kilns (**Common Settings**).

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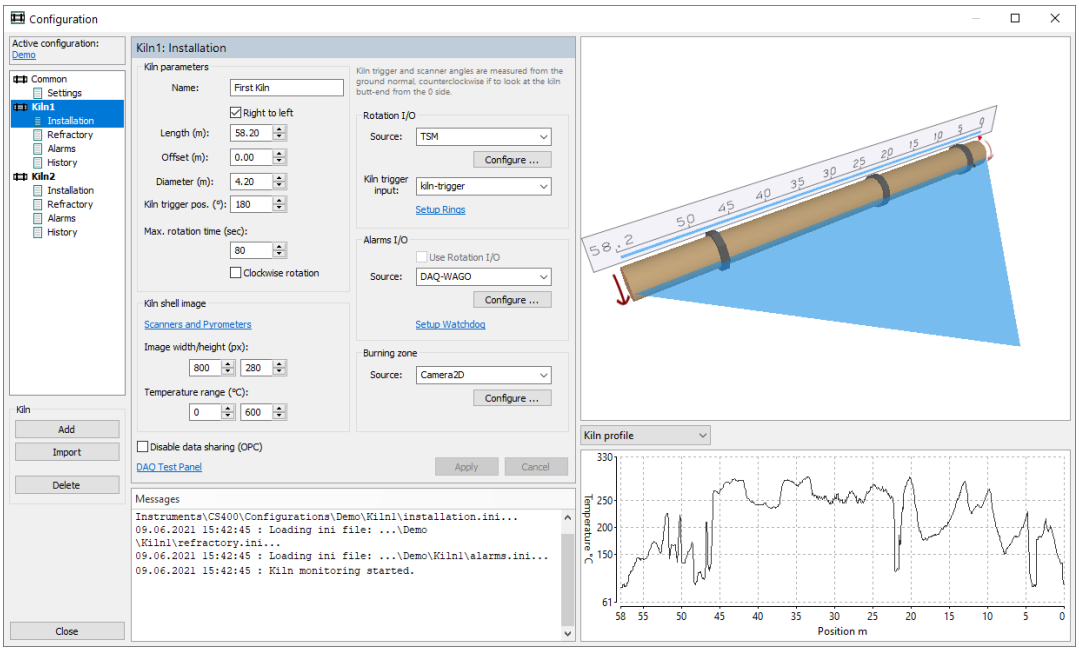

The system configuration can be password protected. In this case, a dialog box appears on the screen asking you to enter the password. Enter the password you were given, or leave the password field blank. In the second case, you will be not allowed to change the configuration settings, you can only view them.

> **Note**
>
> When Configuration window is opened, data received from scanners and other kiln monitoring devices is not processed (alarm conditions are not checked, tire slip values are not calculated, history storage is disabled, monitoring windows are not updated).

In the configuration window for every monitored kiln you should define four sets of settings:

1. **Installation**: parameters and dimensions of the kiln, number and positions of scanners and pyrometers, resulting image size, tire slip monitoring and alarm output devices, burning zone monitoring hardware. See Setting up the kiln and monitoring hardware for details.
2. **Refractory**: brick zones, special zones, drillings and shell repairs. See Setting up kiln refractory for details.
3. **Alarms**: reference envelope profile and alarm zones, tire slip and other alarms. See Setting up alarms for details.
4. **History**: parameters of historical storage of the kiln state. See Setting up history storage for details.

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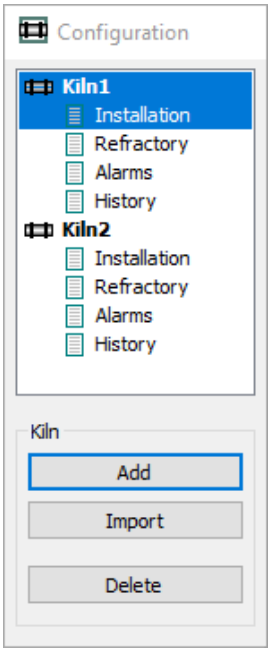
2.3. Kilns monitored on one computer



In the left part of the Configuration window you see the list of kilns and their settings (installation, refractory, alarms and history).

To add a new kiln to the monitoring system, press **Add** button.

To add a kiln configured in CS200, press **Import** button. See Importing CS200 configurations below.

To delete a kiln from configuration, press **Delete** button.

> **Warning**
>
> When you delete a kiln, its settings are permanently deleted from the disk and you will not be able to undo this action.

2.4. Managing configurations

Configuration data is saved in INI files on the local disk. Every kiln has its personal configuration folder, named Kiln1, Kiln2 and so on.

Active configuration

CS400 supports several system configurations. This is useful mainly for demonstration and testing. CS400 running on the plant normally needs only one configuration.

In the start-up screen, use main menu **System \ Configurations** to open the configuration selection dialog:

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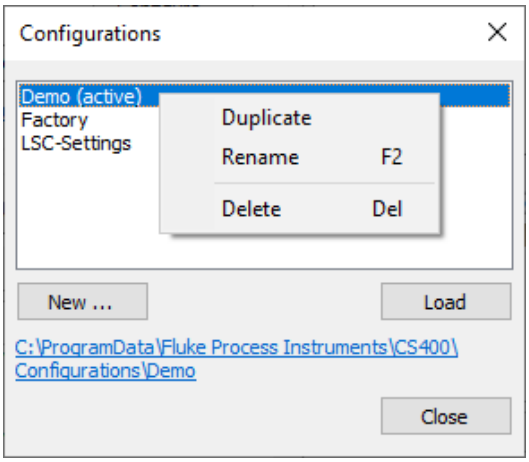
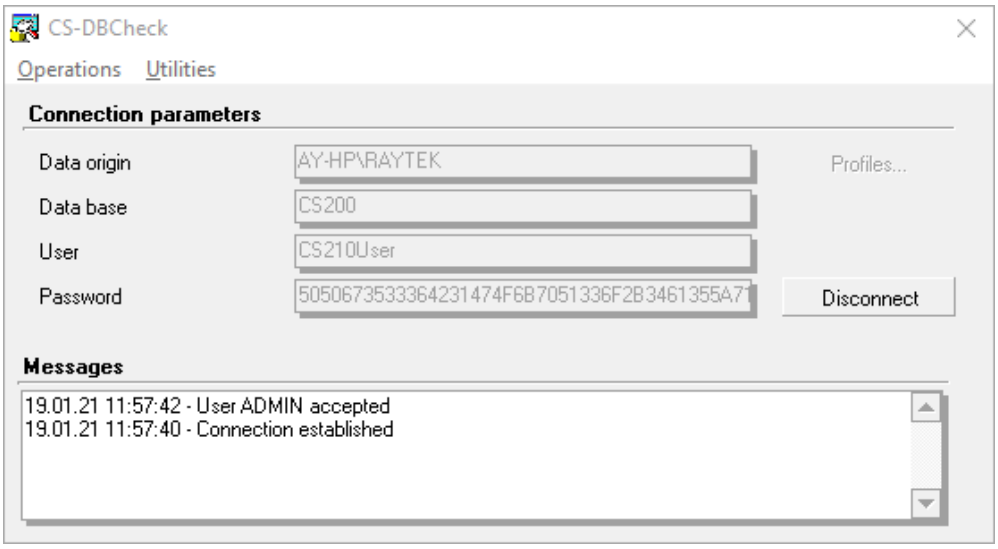


Copying configuration to another computer

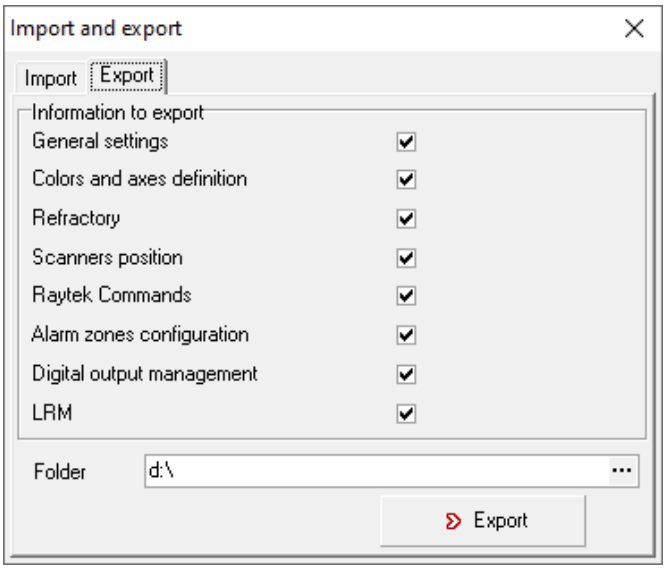
1. Close all monitoring windows to get to the start-up screen. In the main menu select **System \ Export Configuration** and select a file where configuration should be saved.
2. On another computer, open the configuration window and use **Import** button load data from the configuration file you created on step 1. Kilns from the configuration file will be added to the already existing kilns.

2.5. Importing CS200/CS210 configuration

First you need to export CS200/CS210 configuration from the old CS system. Use **CS-DBCheck** tool for this:



After connecting to the CS database, select menu item **Operations | Import and export**:



In **Export** tab mark all check boxes and press **Export** button. Configuration will be saved to the specified folder in a text file named like 20210119120442_ExportCS200.txt. CS200/CS210 configuration contains settings for one kiln.

You can import CS200/CS210 file in CS400 by pressing **Import** button in the left part of the configuration window.

2.6. Kiln dimensions and monitoring hardware

Installation page is protected by Level 2 password.

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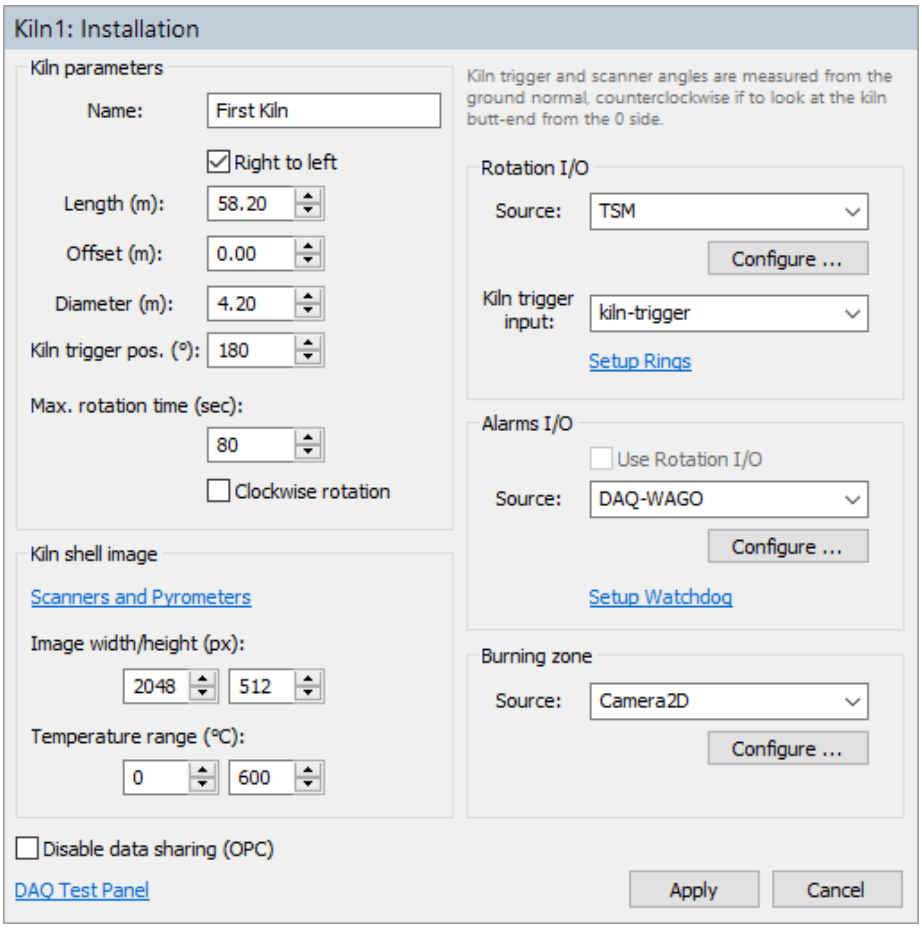

Kiln Parameters

Name: the name of the kiln to be displayed in the monitoring screens. You can use any name you like.

Length: the length of the kiln (or part of the kiln exposed to the IR scanners).

Right to left: if the check box is not marked – kiln axis direction goes from left to right, if marked – kiln axis goes from right to left.

Offset: the kiln position offset. Allows kiln position to begin with value other than 0. Changing this value will change refractory positions accordingly.

Diameter: the diameter of the kiln.

Kiln trigger position: the angle (in degrees) to the kiln trigger sensor. The angle is measured from the ground normal vector, in the counter-clockwise direction if to look at the kiln butt-end from the kiln axis origin side. See the picture below.

Maximum rotation time: the maximum time of one full kiln rotation in seconds. If kiln trigger signal is not coming during this period of time, Kiln-Trigger alarm is generated.

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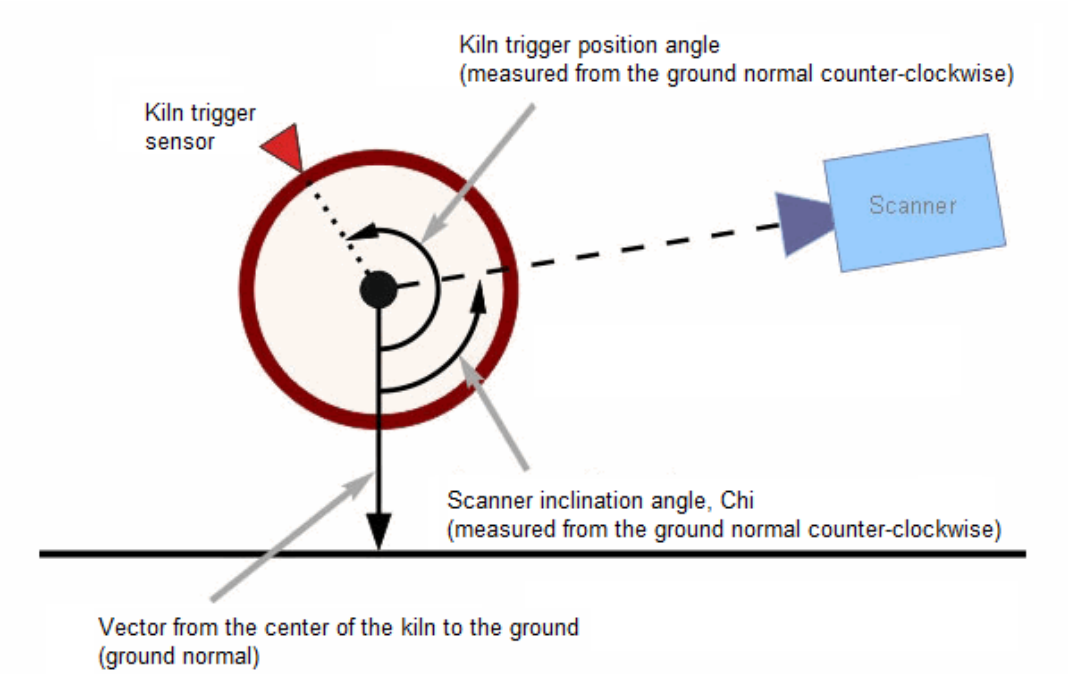
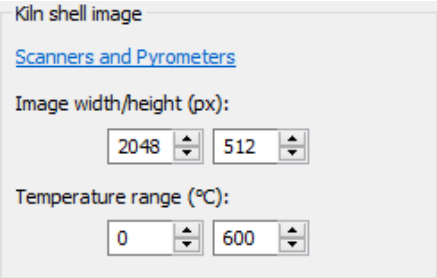
Clockwise rotation: check box marked means that the kiln rotates clockwise, otherwise – counter-clockwise (if to look at the kiln butt-end from the kiln origin side).

Disable data sharing (OPC): if marked, disables remote access to this kiln. It will be not possible to view this kiln using CS400 clients. Also measured data will not be published through OPC.



Kiln infrared image



Temperature data from all scanners and pyrometers is rendered into one kiln shell image. This section defines the parameters of this image.

Image width/height: you can select any width and height values, CS400 will automatically interpolate lacking data or remove redundant data. Please follow these recommendations to get a higher quality kiln image and a better looking monitoring screen:

1. The image width should be close to the number of pixel the scanner line has. If more than one scanner is used in monitoring - the sum for all scanners should be taken.
2. The image height should be selected taking into consideration the size of the smallest spot the monitoring system needs to detect. *Height in pixels = kiln circumference / spot size*. For example,

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if kiln is 3 meters in diameter and we want to have 5 cm resolution, image height = Pi * 3 / 0.05 = 188 pixels. So image height should be 188 pixels or more.

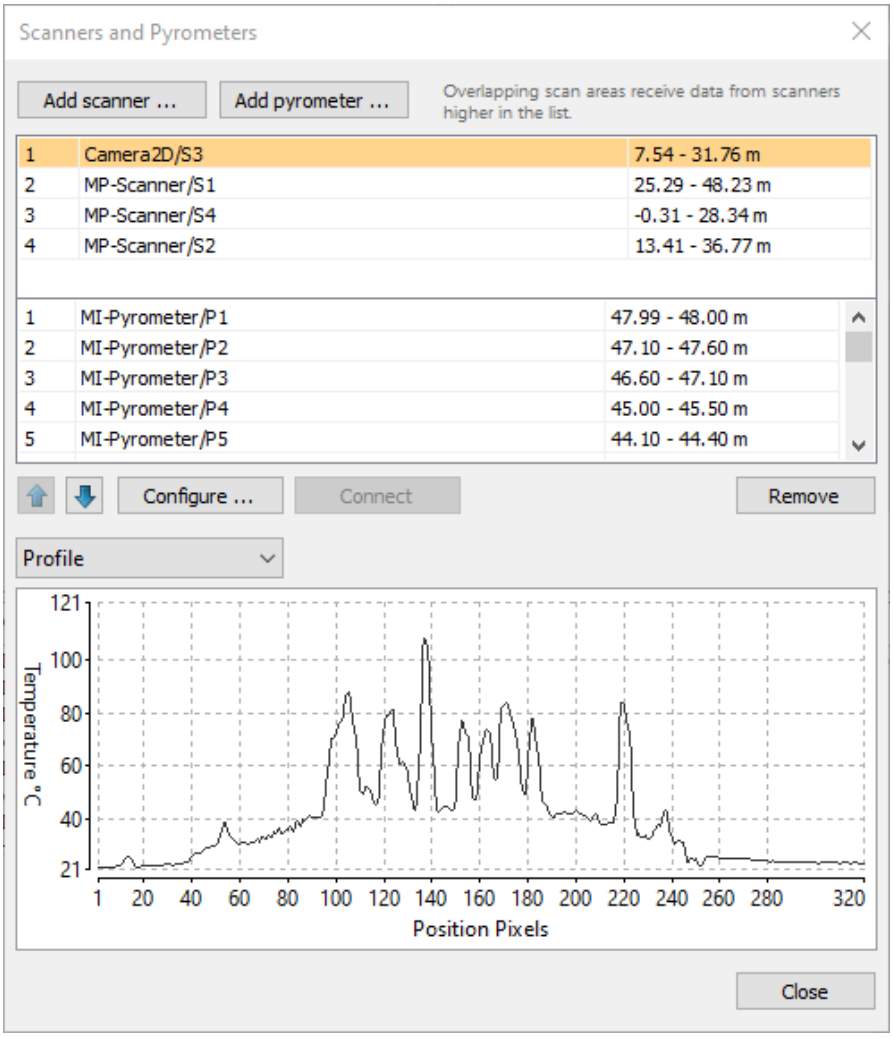
3. If to take into account the way kiln shell image is displayed on screen in CS400 and consider additional windows and analysis, it is better if the image height will be in the range of 1/3 to 1/4 of the image width.

See Kiln shell image composition algorithm for kiln shell image rendering details.

Temperature range: possible minimum and maximum kiln shell temperature. The monitoring system will not be able to display temperatures outside this range.

Scanners and pyrometers

Click **Scanner and Pyrometers** link to display the list of scanners and pyrometers:



To add a scanner to the system press **Add scanner** button.

To add a pyrometer press **Add pyrometer** button.

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To change selected scanner or pyrometer configuration double click on the scanner or pyrometer name in the list or press **Configure** button.

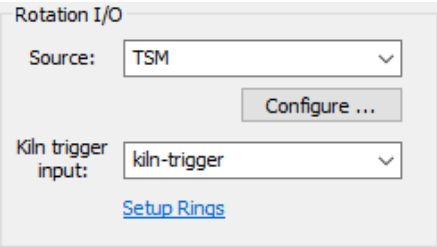
To test a scanner or a pyrometer communication and see its data select the scanner or pyrometer in the list and press **Connect** button. Device data will be displayed in the window below the list.

See Setting up a scanner and Setting up a pyrometer for each device configuration details.

Scanner and pyrometers list order

The order of scanners and pyrometers in the list is important because it affects the order temperature data is rendered to the resulting kiln shell image in the areas where scanners' and pyrometers' FOVs overlap. See Kiln shell image composition algorithm for more details.

Rotation I/O



This section defines hardware used to register kiln revolutions and to measure tire slip values for kiln external rings.

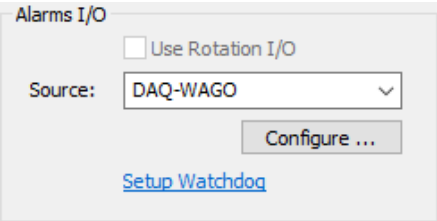
Source: the device type used for signals input (can be TSM, MP-Scanner, DAQ-WAGO and signal simulation timers). Press **Configure** button to configure connection and other parameters of the selected device.

Kiln trigger input: the name of the input used to receive signals from the kiln trigger sensor (different device types use different input names).

Setup Rings: click the link to define kiln external rings and select inputs used by their revolution sensors.

See Kiln trigger and Tire slip monitoring for details.

Alarms I/O



This section defines hardware used to trigger external alarms.

Source: device type used for signals output. Press **Configure** button to configure connection and other parameters of the selected device.

Use Rotation I/O: mark this check box to use the same device for both signal inputs and outputs. Enabled only if selected Rotation I/O device in addition to inputs has also outputs.

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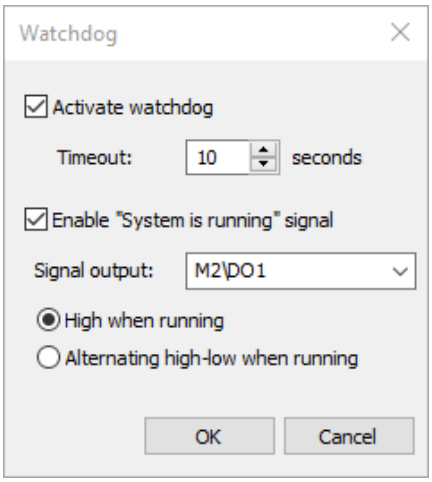
Setup Watchdog: click the link to define parameters of the watchdog. This link is available only if selected I/O device supports watchdog functionality.



"System is running" signal

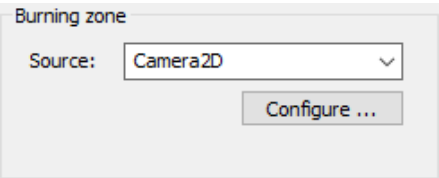
"System is running" signal is not available if the selected alarm I/O device does not support watchdog.

This signal can be used to ensure that kiln monitoring system is running and there are no problems with the monitoring hardware and software:

1. PC is running, CS400 is running, kiln monitoring is started.
2. Devices used for monitoring kiln temperatures are functioning properly: the scanners and pyrometers send data, the kiln trigger signal comes in expected intervals.

> **Note**
>
> "System is running" state is not affected by problems with the ring revolution sensors even if the problems are hardware related.
>
> "System is running" state is not affected by the alarm states (zone alarms, ring alarms and others).

Burning zone



This section defines the device used to monitor the burning zone temperature. This can be an infrared camera (TV40) or an pyrometer (Endurance).

See Burning zone monitoring for details.

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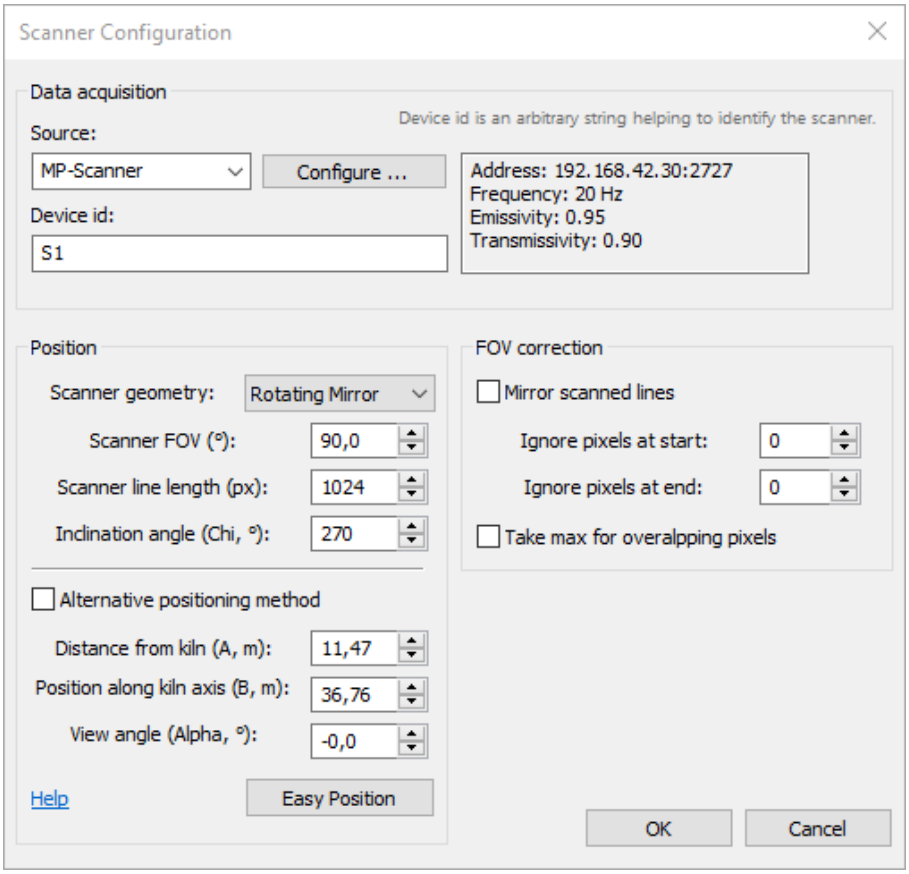
2.7. Scanner configuration



Source: device type used as a scanner (available devices are MP-Scanner, Camera2D). Press **Configure** button to setup up scanner communication and adjust its parameters.

Device id: used to identify the scanner in messages reporting scanner problems and other cases. Can be any text string you like.

Scanner geometry: possible values are "Rotating Mirror" and "Detector Array". This selection will define the perspective correction formula. It is used when the scanner view angle is not zero.

Scanner FOV: scanner's field of view in degrees.

Scanner line length: number of pixels in the scanned line.

> Scanner geometry, FOV and line length are filled automatically after communication with the scanner is established. You can set these values manually in case the scanner is not yet connected to the system.

Inclination angle, Chi: angle (in degrees) from the ground normal to the scanner field of view in counter-clockwise direction if to look at the kiln butt end from the kiln axis origin side.

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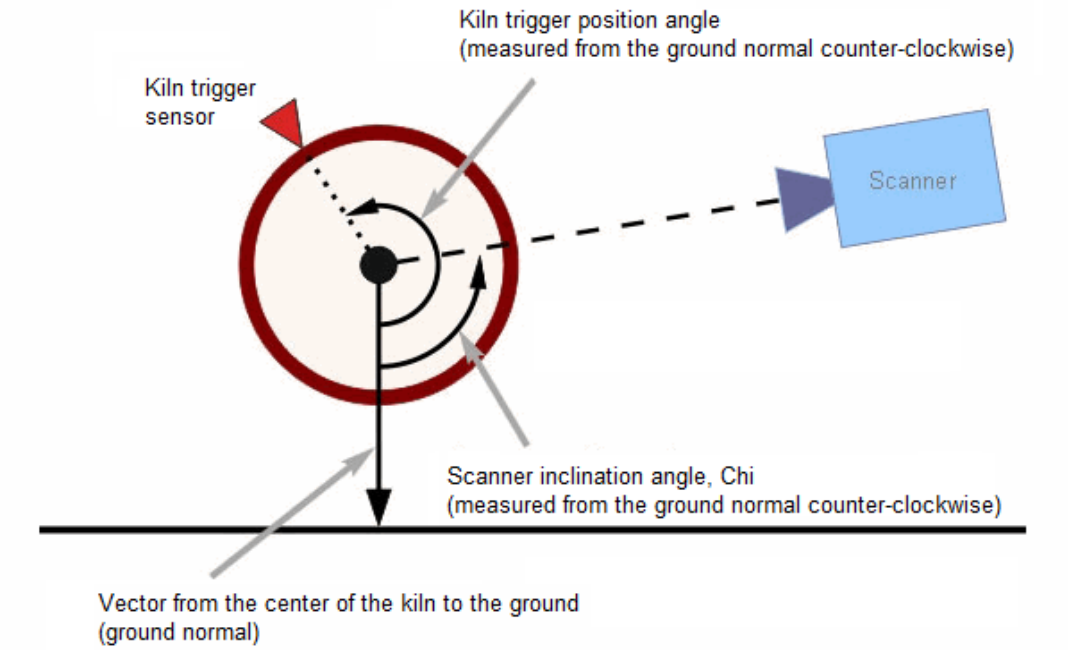
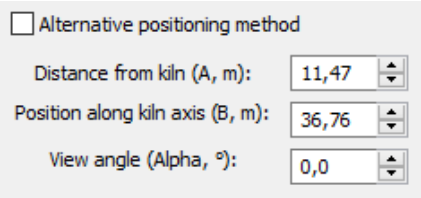


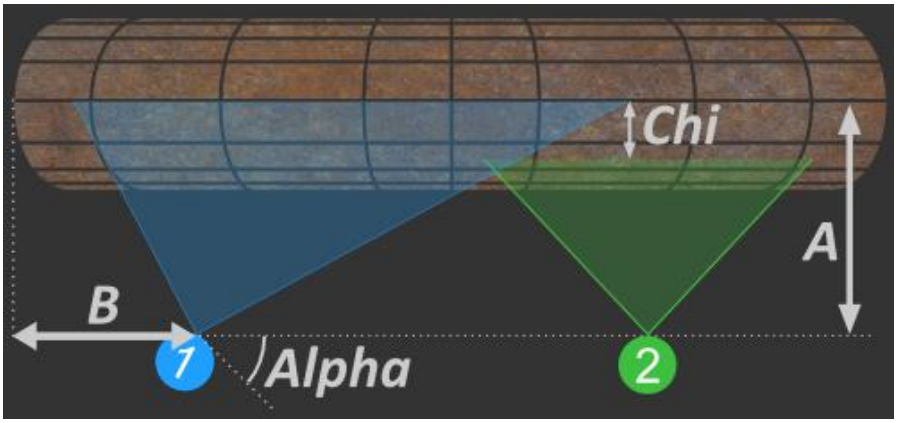
Scanner position



Distance from kiln, A: direct distance from the scanner to the kiln.

Position along kiln axis, B: distance from the kiln origin to the scanner along kiln axis.

View angle, Alpha: scanner view angle, see the picture.



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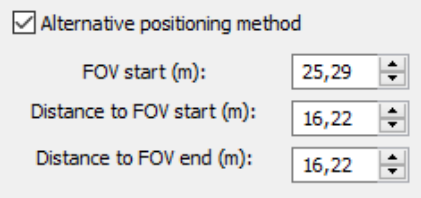
Alternative scanner positioning method

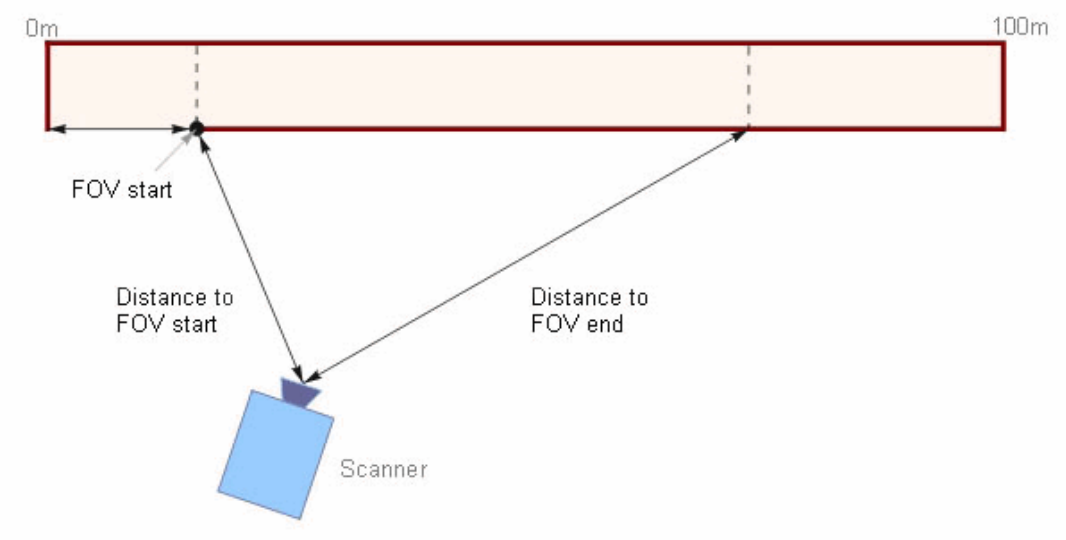


If you mark **Alternative positioning method** check box, you can use different measures to define the scanner position. In some cases this method is more convenient because you do not need to set scanner view angle which is often difficult to measure.FOV

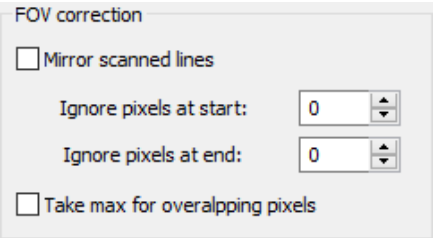
FOV start: coordinate of the starting point of the kiln area observed by the scanner along kiln axis.

Distance to FOV start: distance from the scanner to to the scanner FOV start point.

Distance to FOV end: distance from the scanner to the scanner FOV end point.



FOV correction



Mirror scanned lines: if marked – before processing, every line coming from the scanner is inverted (mirrored). You may want the scanned lines mirrored if, for example, you have scanners installed on different sides of the kiln. In this case, to have the proper image of the whole kiln on the screen, you need to mirror lines from one of the scanners. Another is of this option is if the scanner is mounted upside down.

Ignore pixels at start: number of pixels to ignore at the beginning of the scanned line.

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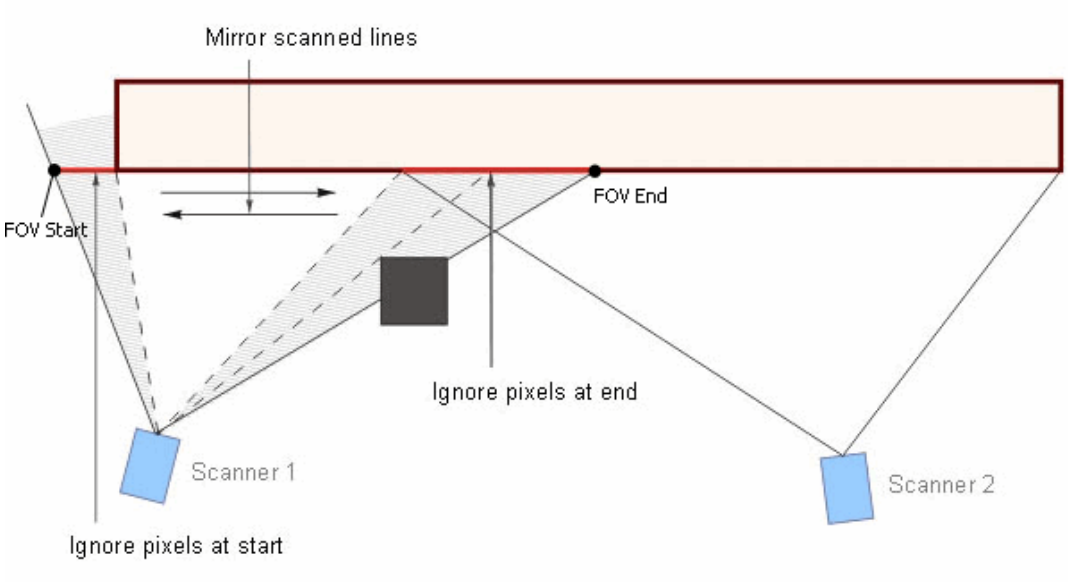
Ignore pixels at end: number of pixels to ignore at the end of the scanned line.

It may be necessary to ignore some pixels at the start or at the end if, for example, the scanner is installed so that its field of view includes some area that does not belong to the kiln, or if on the path from the scanner to the kiln there is a foreign object that gets into scanner's field of view.



Take max for overlapping pixels: another method to solve problems when two scanners FOVs overlap. If this option is selected, when scanned pixels are rendered to the resulting image, the new pixel replaces the underlying pixel only if its value is higher. See Kiln shell image composition algorithm for more details.

Easy Position

Easy Position function allows to set scanner position without measuring distances and angles. It uses scanned data and recalculates the scanner position by coordinates of know kiln objects visible on the scanned data.

You need to define three pairs of corresponding points on the kiln and in the scanned profile. Use objects which you know position for on the kiln and which can be easily identified on the profile: drive gear, live rings, man hole, etc.

Move markers on the profile graph and set the corresponding values in kiln coordinates.

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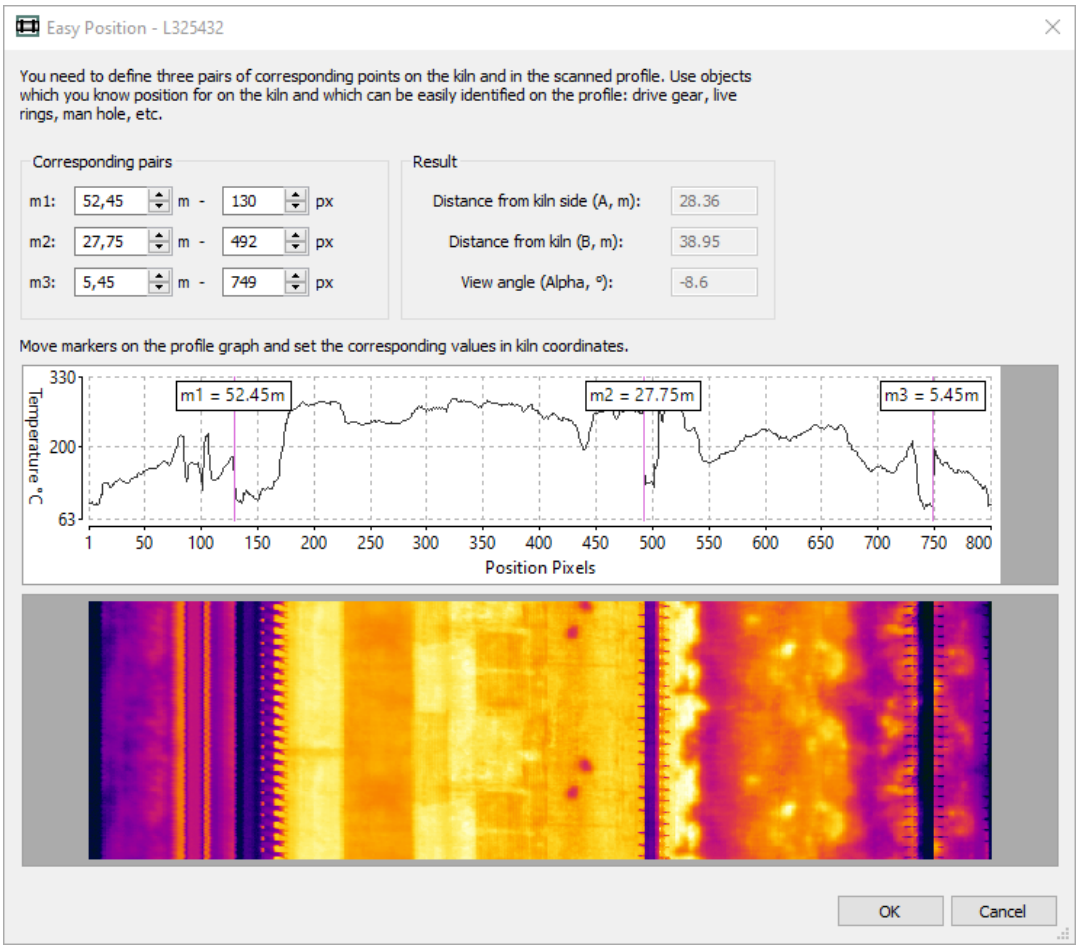

2.8. MP-scanner communication and parameters

MP150 linescanners are supported with Ethernet or RS485 interfaces.

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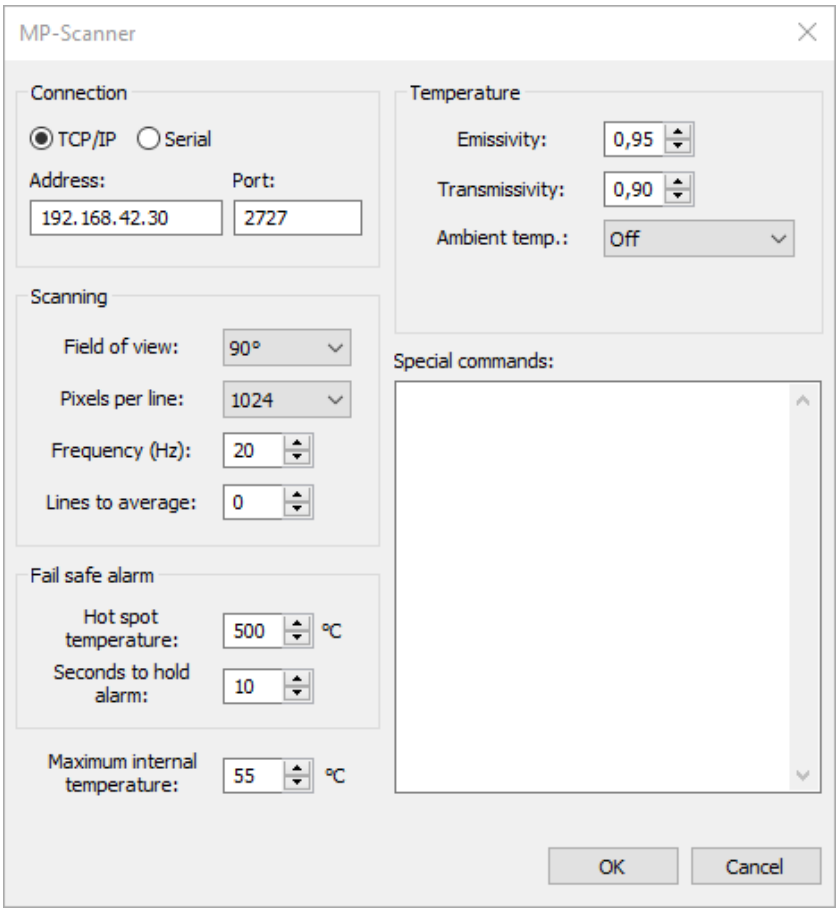

Connection

If your MP scanner has Ethernet interface, select **TCP/IP** and set its IP address (default: 192.168.42.30 for the first scanner; 192.168.42.31 for a second scanner, and so on) and port (default: 2727). For further information to configure the Ethernet communication for scanner and PC network adapter, see MP150 manual. Please note that each scanner in a multiple scanner system requires a unique IP address.

If your scanner is connected to a COM port, use **Serial** option and specify which COM port to use, then select baud rate RS485 interface of the scanner should be configured to.

Baud rate

If selected baud rate does not correspond to the baud rate the scanner is currently expecting communication at, CS400 will try to connect to the scanner at different baud rates, and then, upon a success, will switch scanner's current baud rate to the requested baud rate.

Scanning parameters

Field of view: 90° or 45°

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Pixels per line: normally you should select the maximum value supported by the scanner.

Frequency: 20 Hz is normally more than enough for any kiln monitoring application.

Lines to average: helps to improve temperature accuracy and reduce noise. Please take into account that by enabling averaging you reduce actual scan frequency: *Scan frequency = Selected frequency / Lines to average*.

Temperature parameters

These parameters affect temperature measurement.

Emissivity: the kiln shell usually have surface with high emittance, so emissivity value should be around 0.95.

Transmissivity: this parameter is used to compensate thermal radiation losses because of atmospheric absorption. Depends on the distance from the kiln to the scanner. Usually in the range 0.8 to 1.0. This parameter can also be used if there is an extra window on the path between the scanner and the kiln.

Ambient temperature: compensation for reflected radiation, normally not used because effect is not large comparing to the kiln temperatures.

Special commands

List of additional MP scanner commands that will be executed immediately after connection to the scanner is established. Please refer to the scanner manual for a list of possible commands.

Each command should be on its own line. To have more than one command on a line, commands must be separated with a semi-colon.

Internal temperature

Maximum internal temperature: if the specified temperature value is exceeded, a system state alarm is generated.

Fail safe alarm

To increase reliability of the system it is helpful to have hot spot alarming even when the PC or the software stops functioning. MP scanners provides an internal relay that will be triggered if a hot spot exceeding the predefined limit is detected within the scanner field of view. The relay contacts are available on the terminal line in the system connection box.

Hot spot temperature: if the scanner registers temperature higher than this limit the alarm is triggered.

Seconds to hold alarm: the alarm signal will be held at least this number of seconds even after the hot spot moves away from the scanner view.

2.9. Camera2D communication and parameters

CS400 can use thermal cameras for different purposes:

- The thermal camera can be used both as a primary scanner and instead of a pyrometer to monitor shadow zones. A line on the image is selected which will be the source of data for scanning the kiln surface.

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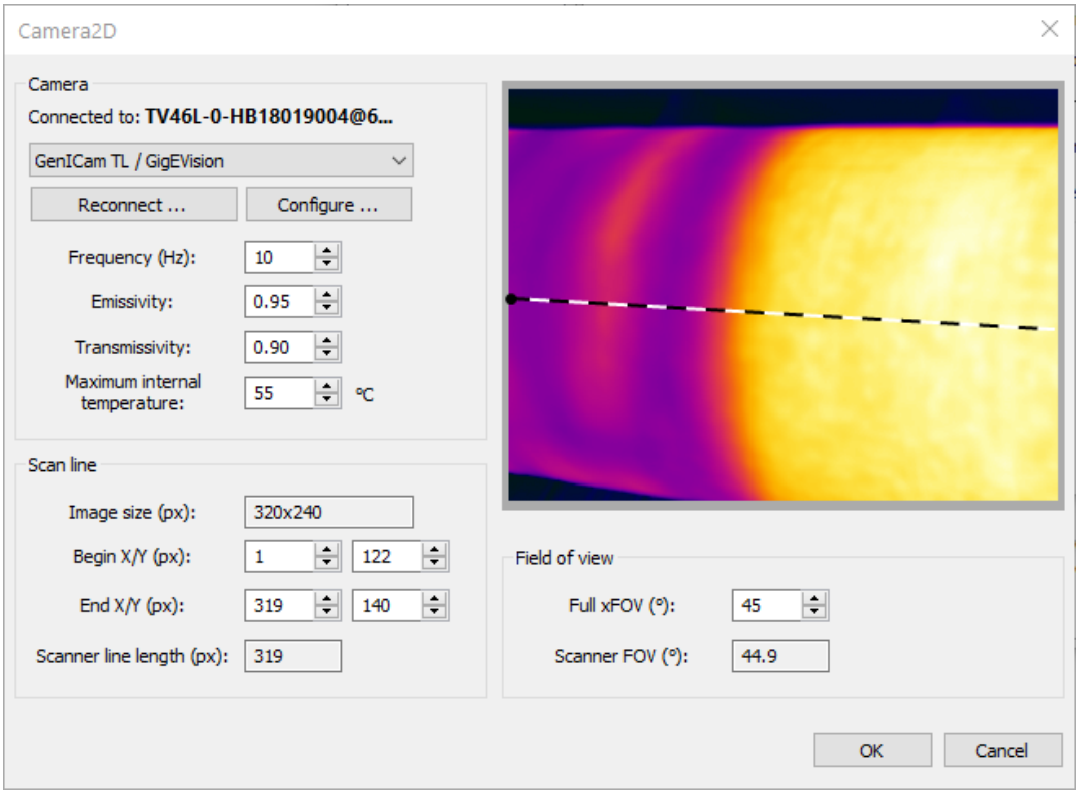
- The thermal camera can be used to monitor the temperature of the burning zone.

Configuration settings are the same in both cases, in the first case you must also select the scanning line:



Frequency: scanning frequency in Hz (or frames per second).

Emissivity: the kiln shell usually have surface with high emittance, so emissivity value should be around 0.95.

Transmissivity: this parameter is used to compensate thermal radiation losses because of atmospheric absorption.

Maximum internal temperature: if the specified temperature value is exceeded, a system state alarm is generated.

Scan line: the source for scan data. You can change the line by clicking on the image. First click will set the begin position, second - the end. The line begin is marked with the black dot.

Field of view: enter the horizontal field of view of the camera which will allow to calculate scan line field of view.

2.10. ThermoView TV40

TV40 series cameras have GigEVision interface and can be connected to a PC using Ethernet cable. When connected to a local area network camera acts as any other Ethernet (IPv4) device and needs an IP address:

- If a DHCP server is available, camera gets IP address from the DHCP server.

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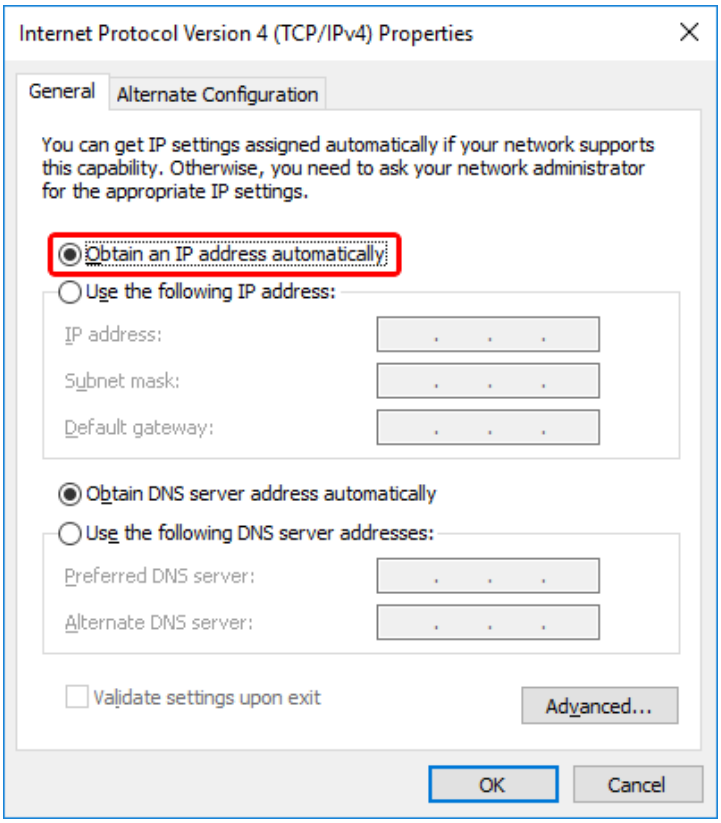
- If there are no DHCP server or camera is connected directly to the Ethernet port of a PC - IP address is selected automatically from the private IP range: 169.254.0.1 through 169.254.255.254.
- It is also possible to set a fixed IP address in an Internet browser using the camera web interface (you need to know current IP address of the camera and type it in the address line).

Configuring network adapter for direct camera to PC connection

You can connect Ethernet cable from the camera directly to the PC, without any router in between. In this case camera IP address is selected from the automatic private IP range.

In order to communicate with the camera, your PC network adapter must be configured to use the same IP range (subnet). The easiest way to do it is to select "Obtain an IP address automatically" option in the TCP/IPv4 settings of the PC network adapter connected to the camera. In this case computer's IP address will be also automatically selected in the same 169.254.X.X range.



Connecting to the camera

1. In the Camera2D configuration dialog, select "GenICam TL / GigEVision" driver and click the **Connect** button:

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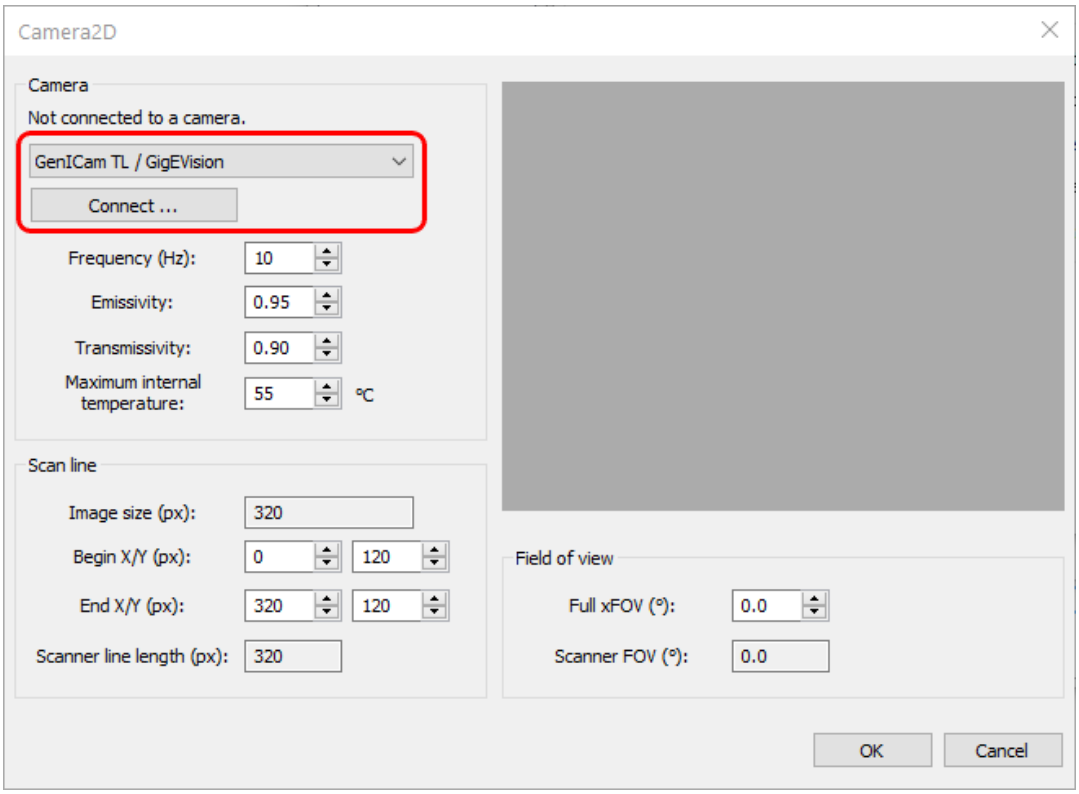
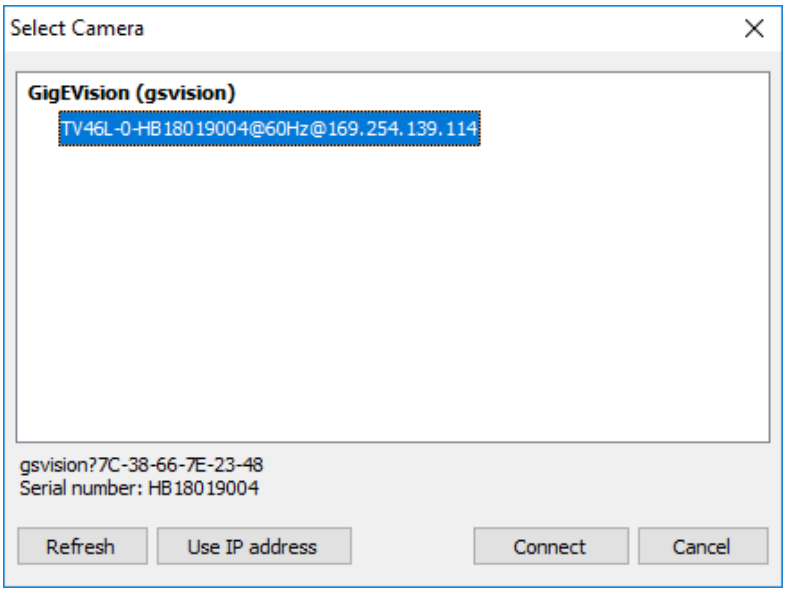


2. Select the camera you want to connect to and press **'Connect'** button. If you do not see the camera in the list, you can try to update camera list by pressing **'Refresh'** button.



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You may see "***other subnet***" text after the camera name. It means that IP address of the camera does not match IP address of the PC: the PC and the camera are in different subnets. If the subnets are not linked by a router connection to the camera will not be possible.

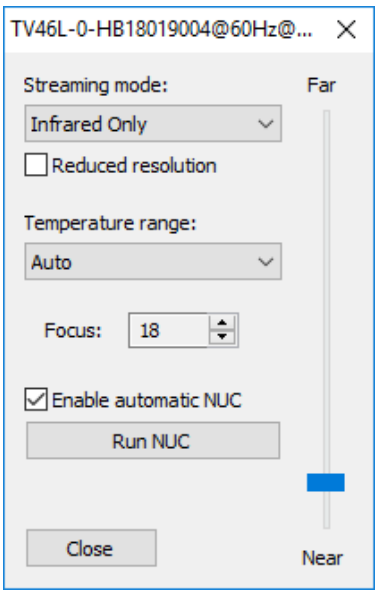
Text "***in use***" after the camera name means that another PC or another program on your PC already established connection with the camera. This will not allow you to connect.

Connecting to camera in another subnet

If the camera and the PC are in different subnets, CS400 cannot detect camera automatically. Reason for this - camera discovery messages are broadcasted and in most cases broadcast messages are not forwarded by routers to other subnets. To overcome this limitation you have to know the IP address of the camera and set it by clicking **'Use IP address'** button.

Changing camera settings: focusing, temperature range, shutter

After you connected to the camera you can change camera settings, like focusing, temperature range and non-uniformity correction parameters. Press Configure button in the **Camera2D** dialog.



Streaming mode

Can be 'Infrared Only' or 'Fusion'. Infrared Only must be selected as Fusion is not used in CS400.

Reduced resolution

This option allows to reduce infrared image resolution by half. Can be useful when you experience problems with losses during data transmission or low PC side performance.

Temperature range

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Your camera is calibrated to measure temperatures in different ranges. If the viewed object has a high temperature and a low temperature range is selected in the camera, measured temperature values will be inaccurate or completely wrong.

'Auto' range: camera will automatically select the appropriate range. Using Auto range is not recommended in Automation mode as range switch may happen during an important measurement. Range switch procedure takes several seconds, during this period measured values may be absolutely wrong.

Focus

Allows to drive motorized focus position. Displayed focus position number has no physical meaning. Use **'Near-Far'** slider to change focus position. Focus edit box spin buttons are handy for fine focus changes.

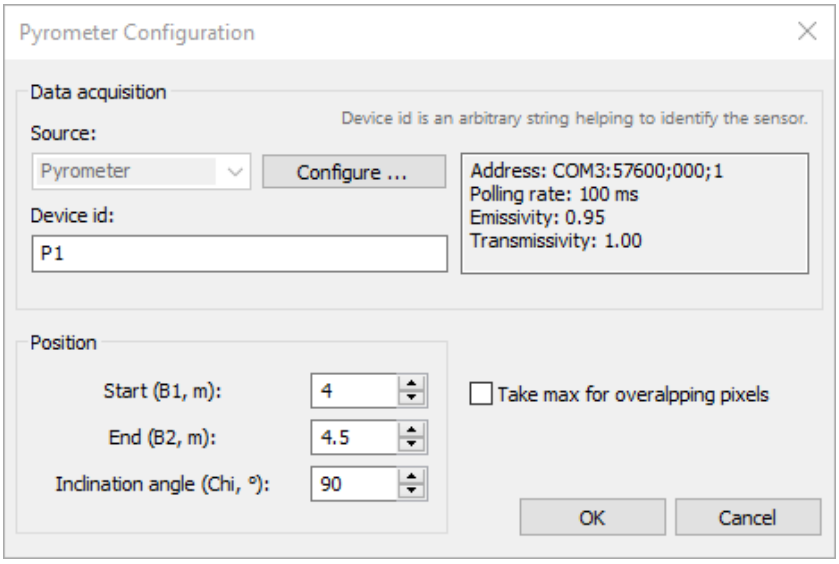
Enable automatic NUC

When enabled, camera will run non-uniformity correction procedure at moments of time it selects automatically by measuring the sensor temperature.

Run NUC

Press this button to tell camera to execute non-uniformity correction.

2.11. Pyrometer configuration



Source: device type used as a pyrometer, only "Pyrometer" source is supported. Press **Configure** button to setup up pyrometer communication and adjust its parameters.

Device id: used to identify the pyrometer in messages reporting problems and other cases. Can be any text string you like.

Pyrometer position

A pyrometer measures temperature in a single spot. Its position defines area of the kiln that should be overwritten with the pyrometer measurements.

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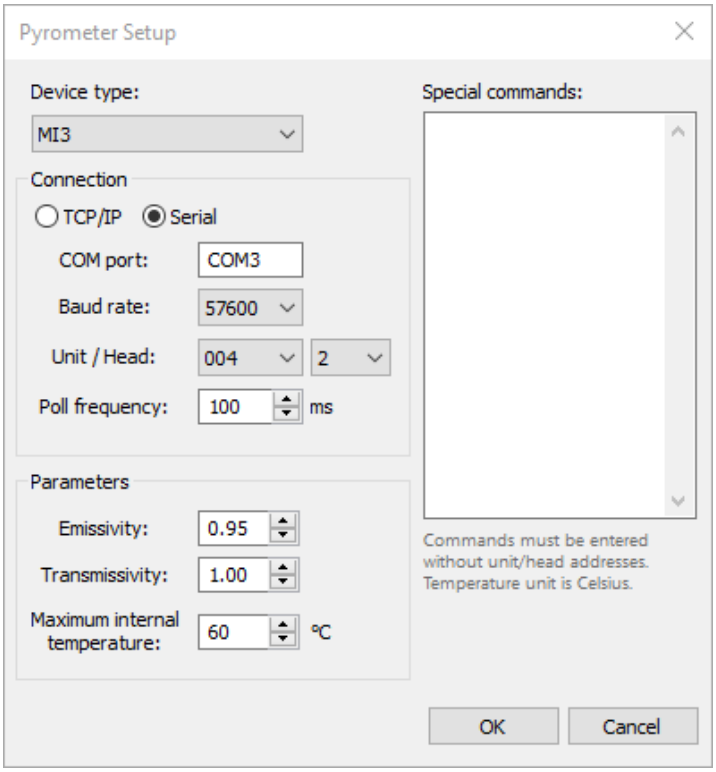
Start, B1: position along the kiln axis that defines pyrometer area begin.

End, B2: position along the kiln axis that defines pyrometer area end.

Inclination angle, Chi: angle (in degrees) from the ground normal to the scanner field of view in counter-clockwise direction if to look at the kiln butt end from the kiln axis origin side.

Take max for overlapping pixels: If this option is selected, the pyrometer measurement replaces the scanner measurements only if its value is higher. See Kiln shell image composition algorithm for more details.

2.12. Pyrometer communication and parameters



Device type

Supported devices include Endurance, MI3 and Thermalert 4.

CS400 does not support configuration of all parameters a pyrometer may support, it only polls already configured devices. Some extra parameters can be set using Special commands, but communication related parameters like baud rate, multidrop address or IP address must be configured in the special software delivered with pyrometers.

Connection

Depending on your device type connection can be **TCP/IP** or **Serial**. Serial is used when RS485 device is connected to a COM port. TCP/IP is used if the pyrometer has Ethernet interface or if you

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connect RS485 pyrometer with RS485 to Ethernet converter without virtual COM ports (see RS485 to Ethernet converter below).

Baud rate: you should select the baud rate that matches the baud rate the pyrometer is currently configured for. If baud rates do not match, communication is not possible, baud rate auto negotiation is not supported.

Unit: RS485 multidrop unit address.

Head: head address for devices that support several sensing heads (MI3).

Poll frequency: CS400 will try to poll the pyrometer for measured temperatures at this rate. The selected rate might not be achieved when response time of the device is slower or when there are several devices connected to the same RS485 multidrop network. Also sometimes it makes no sense to poll too frequently as pyrometer may not update its reading fast enough. Please consult the pyrometer manual for response times and update frequencies.

Parameters

Emissivity: the kiln shell usually have surface with high emittance, so emissivity value should be around 0.95.

Transmissivity: this parameter is used to compensate thermal radiation losses because of atmospheric absorption. Pyrometers are usually installed close to the kiln, so transmissivity is normally close to 1.0.

Maximum internal temperature: if the specified temperature value is exceeded, a system state alarm is generated.

Special commands

List of additional pyrometers commands that will be executed immediately after connection to the pyrometer is established. Please refer to the pyrometer manual for a list of possible commands.

Each command should be on its own line. To have more than one command on a line, commands must be separated with a semi-colon.

Commands should be entered without unit/head addresses! Temperature unit in commands is Celsius.

RS485 to Ethernet converter

The usual way of connecting an RS485 device to a PC is to use special RS485 boards or RS485 to RS232 converters and talk to the device through a corresponding COM port. There is also another possibility - to use an RS485 to Ethernet converter. Such converters work in a way that they convert RS485 data into TCP/IP packets and back. On the PC side they create virtual COM ports and send data through them as if the remote device is directly connected to the PC COM port. This fully simulates serial communication and PC software does not even know that Ethernet is used in the middle.

Converter to Ethernet can also work without creating virtual COM ports on the PC side. Then they just convert RS485 data to TCP/IP packets and PC software should establish connection using TCP sockets. CS400 supports this method as well - use the Ethernet connection option.

Advantech EKI-1524

Here is a only a brief description for the two modes for Advantech EKI-1524 converter. For details please check the CS400 hardware manual.

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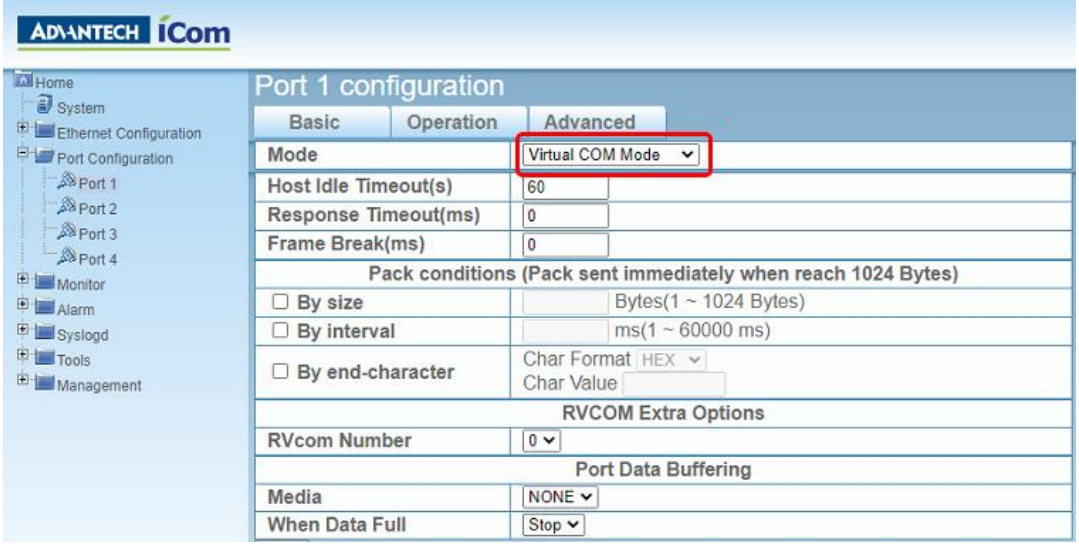
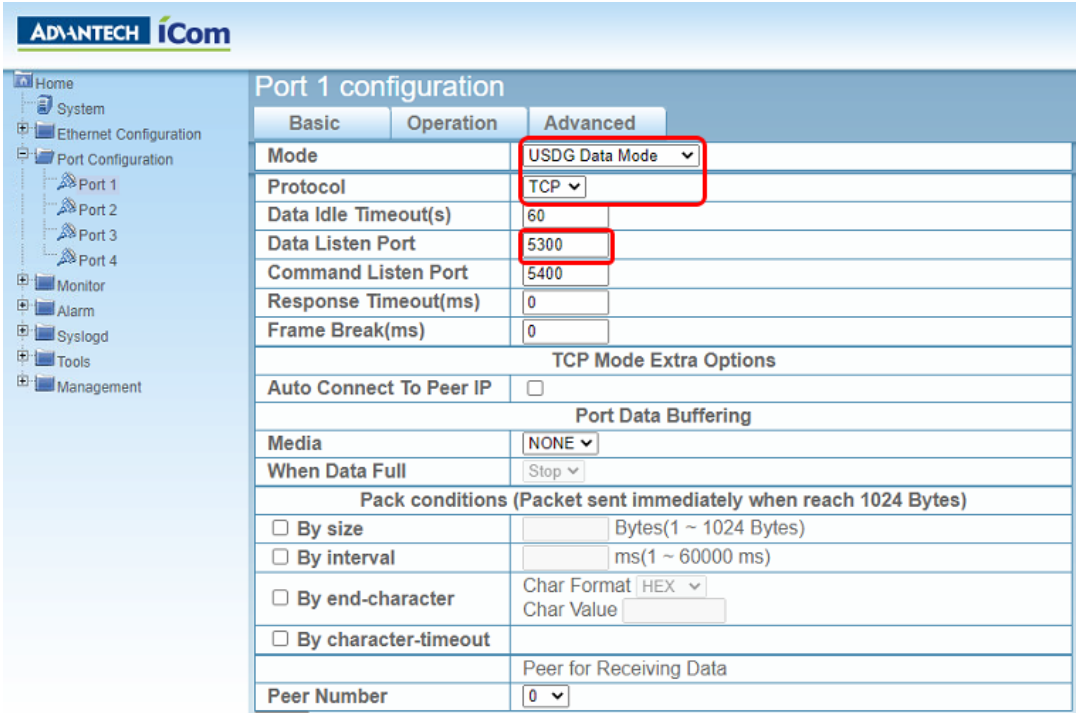


In the port configuration if you select **Virtual COM Mode**, you will need to install Advantech software on the PC and use virtual COM ports there.

You can also use **USDG Data Mode** with TCP protocol. Then Advantech software and virtual COM ports are not needed on the PC side. In CS400 you select Ethernet connection option. IP address is the address of the EKI-1524 device and Port is the port number selected in the EKI-1524 Port configuration:



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2.13. WAGO 750-362 field bus coupler

WAGO 750-362 (750-352) fieldbus coupler is used to output alarm and analog signals to the plant automation system.

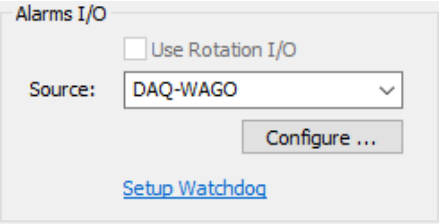
These WAGO 750 extension modules are tested and supported:

- Digital output module 750-1504;
- Relay output modules 750-513, 750-517;
- Analog output modules 750-562, 750-563;
- Digital input module 750-1406.

Proper work of other modules is not guaranteed.

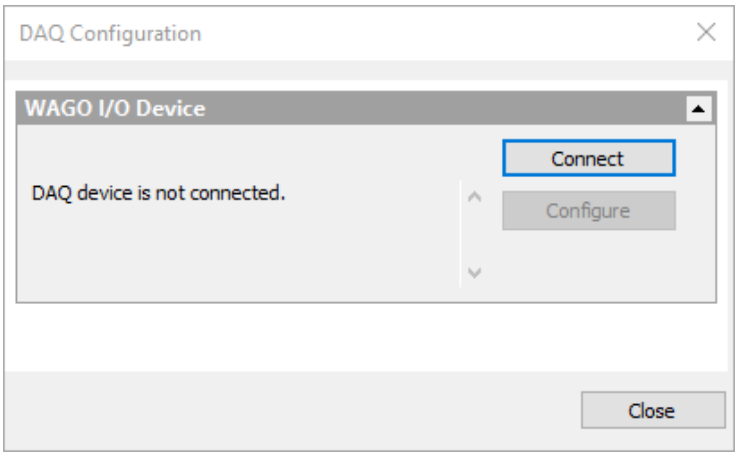
> If an unsupported module is used, CS400 may not be able to address the inputs and outputs correctly even in the supported modules. Because of this the program will not allow connection to the device.

To set a WAGO coupler to be used as the output device, select **DAQ-WAGO** as the source for Alarms I/O on the Installation configuration page:



Press **Configure** to establish communication with the WAGO module (it must be already connected to the computer) and to change communication parameters.

First you will see **DAQ Configuration** dialog:



Press **Connect** to connect to the device.

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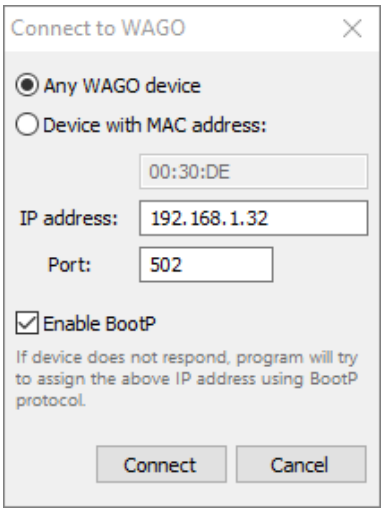

MAC address

If you have several fieldbus couplers in your network, you need to select to which of the available couplers to connect. The identification is done using the MAC address. There is a sticker with unique MAC address on every WAGO fieldbus coupler.

If you have just one fieldbus coupler, select Any WAGO device option.

IP address

WAGO fieldbus coupler supports several methods of IP address assignment. You can read about them in the WAGO fieldbus coupler documentation. In this manual you will find description of methods that we recommend to use. Please see it below.

Port

If not changed in fieldbus coupler configuration, port used to exchange data with the fieldbus coupler is 502 (default for Modbus protocol).

Enable BootP

Mark the check box to enable BootP protocol on the PC side.

Using BootP protocol to connect to a WAGO device

May not work if device's factory default configuration is changed.

We recommend to use BootP protocol for IP address assignment. This is also the default method - WAGO fieldbus coupler has BootP enabled in the factory default configuration.

Before you try to connect to your WAGO device, please make sure that all switches on the red DIP switch on the fieldbus coupler case are set to 0. On the picture below, all switches (white) are moved to the right, OFF side.

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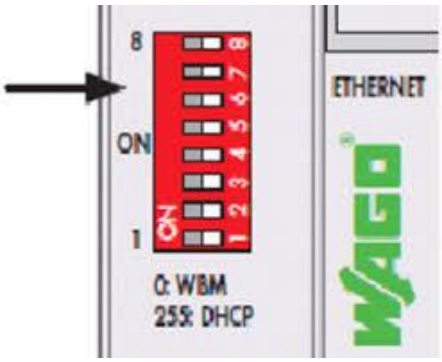

You need to select proper IP address that will be assigned to the WAGO fieldbus coupler:

IP address of the WAGO device must belong to the same subnet with PC's network adapter to which the coupler is connected to. For example, if PC's network adapter has IP address 192.168.1.X, for the fieldbus coupler you should select IP address which also starts with 192.168.1. Make sure that no other PC or network device uses the same IP address.

To know which IP address your PC adapter has you need to find the adapter in Windows settings and check its properties.

Please also consider the following:

- If WAGO device already has an IP address assigned, it cannot be changed with BootP.
- BootP server is running only during the connection process. It is stopped as soon as appropriate WAGO device is found and connected.
- IP address negotiation with BootP protocol may take some time, but not longer than two minutes.
- If IP address assignment takes too long, you may try to restart (power-on reset) the WAGO device, then it will send a BootP request immediately after booting.
- If BootP is used as the IP address assignment method, you should leave 'Enable BootP' option on as the BootP-assigned IP address is not remembered when WAGO device is rebooted.

Using DIP switch to set IP address

Again we assume here that factory default configuration of WAGO fieldbus coupler is not changed.

Default WAGO IP address starts with 192.168.1 and you can use the red DIP switch located on WAGO device case to set the IP address last number. There are 8 switches which allows to select a number from 0 to 255 in the binary form:

- **0**: WAGO WBM (web based) configuration is used, which has BootP method enabled (factory default). This is the BootP option described above.
- **1-254**: WAGO device will have fixed IP address 192.168.1.1-192.168.1.254, BootP protocol will not be used.
- **255**: WAGO device will use IP address assigned by a DHCP server (DHCP server should be available on LAN where WAGO device is connected to). This option is not recommended as DHCP assigned IP addresses are often dynamic and there is no easy way to know which address was used.

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You should set 'IP address' field in 'Connect to WAGO' dialog to the same value as was configured by the DIP switch.

Other IP address selection methods

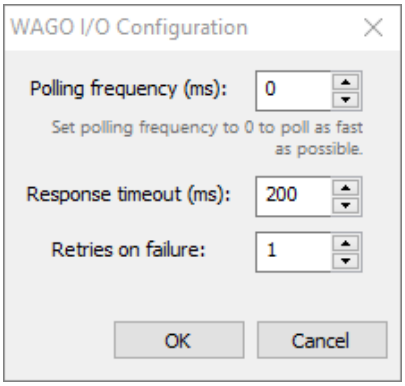
BootP and the DIP switch is not the only methods of IP address configuration. Fieldbus coupler settings can be also changed in Web-based Management System (WBM). If they are changed, methods described above may not work. Please read WAGO documentation for details.

Configuring data exchange delays for WAGO fieldbus coupler

Modbus TCP protocol is used to read input signals and to set output signal values. The protocol works in a way that PC program sends a request to the WAGO device and WAGO device reports current state of the inputs. You can configure how often to check the state of the inputs. The faster your controlled process is the higher should be the polling rate, but there are limitations.

> In perfect conditions (short Ethernet cable, no interferences) it takes about 2 ms for WAGO device to respond. This allows to read input states about 500 times per second. Windows is not a realtime OS, at some moments response time may fall to about 20-40 ms.

To open WAGO configuration dialog press **Configure** button in the **DAQ Configuration** dialog.



Polling frequency

Specify the delay in the polling requests in milliseconds. 10 ms delay corresponds to 100 requests per second. If you set the delay to 0, polling will be done at the maximum frequency. This frequency is limited by WAGO filedbus coupler response time and the network capabilities. Practically the maximum frequency that can be achieved is 400-500 Hz (2-3 ms delay between requests).

Response timeout / Retries on failure

This is the time in milliseconds PC waits for a response from the WAGO fieldbus coupler. If response is not coming in this time, fieldbus coupler failure is suspected. Program will try to repeat the request. Number of such requests is defined by 'Retries on failure' field. If after the retries response is still not received, a connection loss state is reported.

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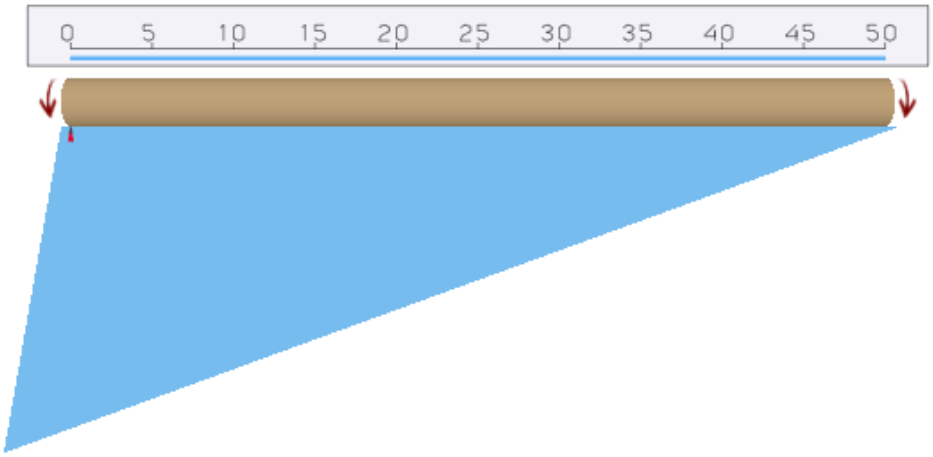
These timeouts are used only during device polling.

And to establish connection with the WAGO device, timeout values from an INI file are used. Please check *ConnectResponseTimeoutSec*, *ConnectRetryCount*, *BootPTimeoutSec* parameters in **gsmodbus.ini** file located in the program installation folder.

2.14. Kiln shell image composition algorithm

Resolution compensation

For scanners with rotating mirror technology object area covered by each scan line pixel differs along the line. This is also true for devices with detector array technology (like 2D IR cameras), when the device is looking at the kiln not straightly. This pixel resolution difference are automatically compensated by CS400.



Scanned data gathering and position around the kiln circumference

1. For each scanner and pyrometer temperature data scanned during the period between two kiln trigger signals are buffered in the memory. Each line is stored together with its timestamp.
2. Memory buffer size for one revolution is limited to 4096 lines (constant, cannot be changed) per each scanner and pyrometer. In extreme cases (slow kiln rotation, fast scanning rate), when the buffer is full and a new line is received, every second line is removed from the buffer to free space.
3. When the kiln trigger signal is received the buffered lines are used to render next kiln shell image.
4. Line timestamps are used to map scanned lines to kiln shell image lines.
5. If several scanned lines correspond to one image line they are merged using the maximum operation.
6. If there are no scanned lines found, the image line is interpolated using scanned lines with the closest timestamps.
7. If kiln rotation speed is changing CS400 estimates acceleration and corrects lines distribution accordingly. This is done automatically, no configuration is needed.

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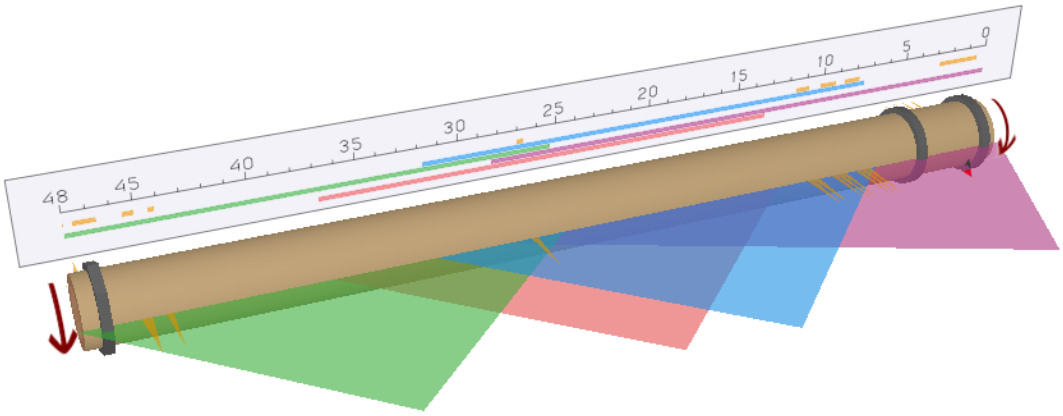
Scanner and pyrometer data render order

The fields of view of the scanners may overlap. The positions of the pyrometers may also overlap, both with each other and with the scanners.



You need to decide what source to use for overlapping areas.

The rules are:

- Pyrometers always have higher priority than scanners: pyrometers measurements overwrite scanners measurements.
- If two devices fields of view overlap, the device higher in the list overwrites measurements of the device lower in the list.
- If a scanner or a pyrometer has "Take max for overlapping pixels" option enabled its measurements overwrite other measurements only if they have bigger temperature value.

2.15. The kiln trigger

CS400 monitoring system updates its measurements and alarms once per full kiln revolution. To know that kiln has made a full revolution a sensor is needed. Usually this is a proximity sensor installed on the kiln.

Device that sends signals after each kiln revolution is called **kiln trigger**.

Configuration

You should define an I/O device that is used to receive signals from kiln rotation sensors and select an input that corresponds to the kiln trigger signal. This is done in Configuration on the Installation page:

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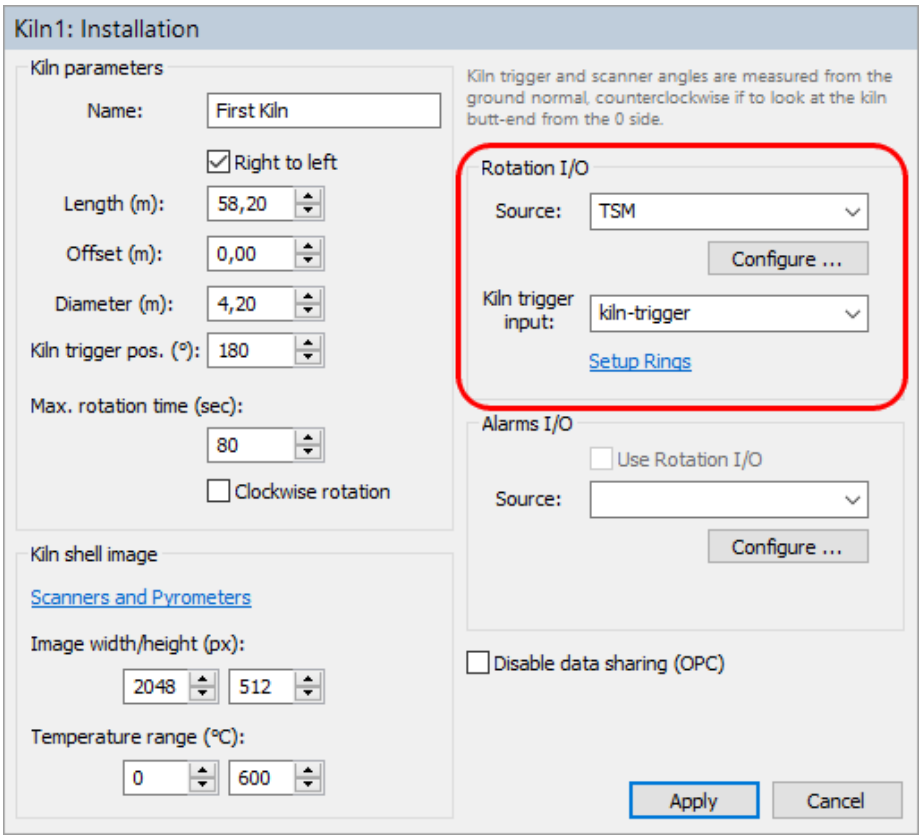
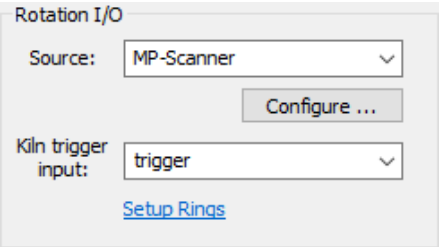


TSM device

If your monitoring system uses TSM device, select **TSM** as Rotation I/O source. As Kiln trigger input select **kiln-trigger**.

MP scanner as kiln trigger source

You can use the MP scanner trigger input to connect kiln trigger sensor to the system. To do so as Rotation I/O source use MP-Scanner. As Kiln trigger input select **trigger**.



If you have more than one MP scanner in the system, you also need to define which scanner to use. Press **Configure** button and enter the corresponding scanner ID (a unique part of the scanner ID):

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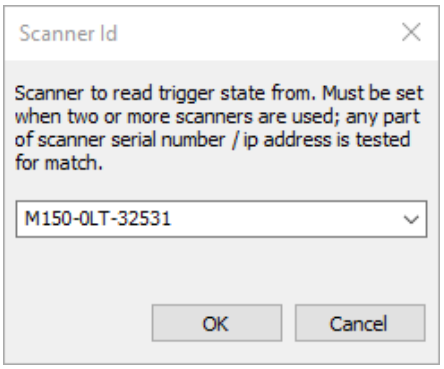


No signal from kiln trigger, Kiln-Trigger alarm

Having stable and reliable kiln trigger signal is very important. There are several abnormal situations related to kiln rotation that the system must handle properly.

If kiln is not rotating or rotating too slowly or if kiln trigger sensor does not function monitoring system will not receive kiln trigger signal in time. **Kiln-Trigger** alarm is generated If there is no signal from the kiln trigger within the period defined by **Max. rotation time** parameter.

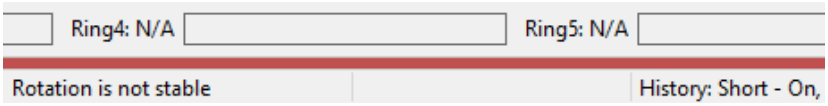
In case there is no kiln trigger signal, kiln shell image is updated after max. rotation time passes. Such kiln shell images contain more than one revolution if kiln rotation is too slow, or less than one full revolution in case kiln trigger sensor is broken. These images are still valid for zone alarms and envelope alarms conditions, alarm states are updated.

Kiln shell images without correct kiln trigger signal cannot be used to update brick thickness map and are not saved to the history.

Kiln rotation speed is not constant

It is sometimes required during production process to change kiln rotation speed. When speed is changing consequent kiln shell images are slightly distorted in the vertical direction. This has no influence on alarm conditions detection, but does not allow to compare kiln shell images one with another. It is better not to use such images in the brick thickness calculation, so they are not used there and also not saved to the history.

There is no alarm for not constant rotation speed. If rotation is not stable or not measured a warning text is shown on the monitoring window status bar:



To detect that kiln speed rotation is changing CS400 compares several consecutive revolution times and calculates their variation (maximum - minimum). If measured variation is too big, corresponding kiln shell images are marked as not stable and are not used in brick thickness calculation and are not saved to the history.

Parameters used for rotation stability measurement are taken from Linescano.ini file:

```
[ROTATION]
stability_samples_count: number of revolutions used to calculate rotation
variation;
```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acceptable_revolution_time_variation: maximum variation value (in seconds) that is considered as stable.

False kiln trigger signals

Contact bounce is easily filtered out by defining a minimum value for time between two consecutive signals.

There is also a filtering mechanism available to detect false signals that come from a not properly working system (with, for example, randomly induced interference). This filtering works like this.

- Average revolution time is constantly maintained by averaging signal periods from last N revolutions.
- When a new signal comes and its period differs from the average by more than X percent, this signal is ignored.

It is possible to adjust signal filtering (and to turn it off) by editing parameters in Linescano.ini file:

[ROTATION]
false_signal_filter_minimum_time: minimum time between two signals in seconds. If next signal comes earlier, it is ignored;
false_signal_filter_size: number of consequtive signal periods used to calculate average rotation time, 0 to turn filtering off;
false_signal_filter_accept_difference: 0..1 (1 corresponds to 100%) - difference to the average rotation period that is still acceptable.

2.16. Tire slip monitoring

Kiln design normally includes external rings (tires) that support the kiln hull. Rings are not fixed to the kiln and have a slightly bigger than the kiln diameter. Rings are not rotated – kiln rotates the rings. Because of temperature change inside the kiln, kiln diameter varies. If kiln diameter becomes bigger than the ring diameter, the ring will damage the kiln. Rings diameter should be all the time bigger than the kiln diameter.

Tire slip is the difference between kiln circumference and ring circumference (measured in millimeters or inches).

$$tire\ slip = \pi D \frac{T_{ring} - T_{kiln}}{T_{kiln}}$$

T_{kiln} – kiln revolution time

T_{ring} – ring revolution time

D – kiln diameter

CS400 includes monitoring system (**TSM**), that measures tire slip for each ring and generates alarms when measured values exceed defined limits.

Tire slip monitoring system needs sensors that generate signals every time a ring makes full rotation. When the kiln or a ring makes a full rotation, the system gets a signal from the kiln trigger sensor or a ring sensor, so that kiln and ring rotation time is known and can be compared. CS400 calculates tire

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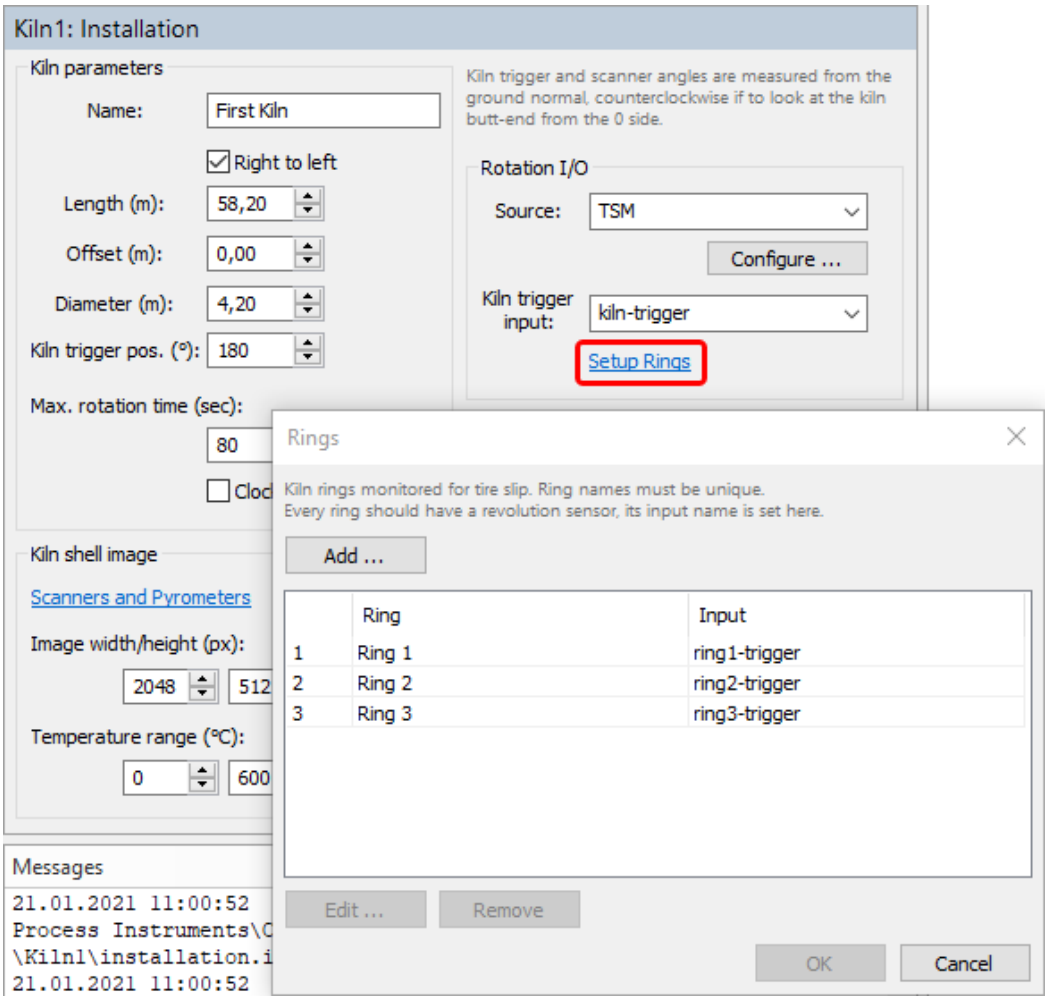
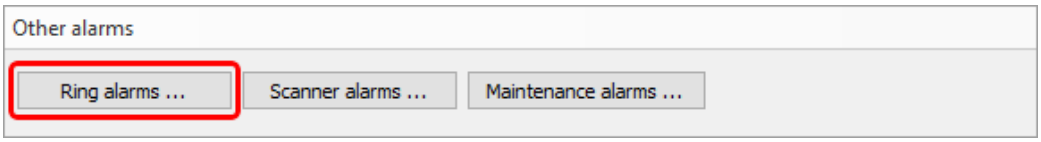
slips of all rings and generate alarms if calculated values are out of the predefined range. Alarm is also generated if we have not got the signal during the period of maximum kiln rotation time.

Configuration

You need to define the rings and select I/O device inputs used for each ring. This is done on the Installation page:



To define allowed tire slip limits for each ring, go to the **Alarms** page, **Other alarms** window:



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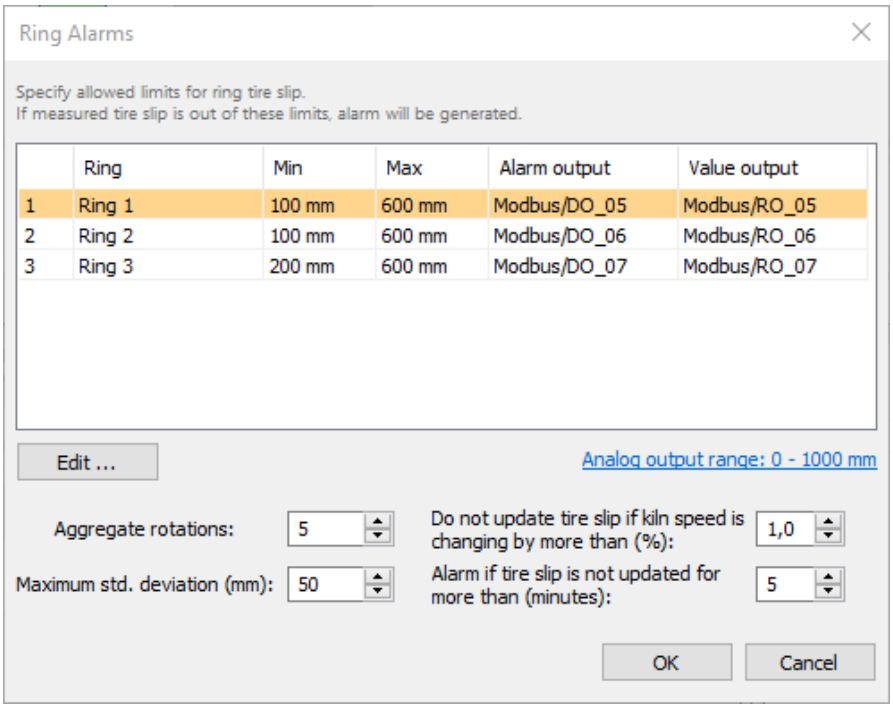

Tire slip value measured by one revolution may not be accurate enough. To improve the accuracy CS400 averages values from several kiln revolutions.

Aggregate rotations: number of revolutions that are used to measure tire slip value more accurately.

Maximum std. deviation: allowed standard deviation for values measured at each revolution. Number of revolutions for standard deviation calculation is defined by Aggregate rotations parameter. If standard deviation exceeds the allowed value, ring alarm is generated.

Varying kiln rotation speed

If kiln rotation speed is not constant, measured tire slip values will be inaccurate and cannot be used to trigger alarms.

Do not update tire slip if kiln speed is changing: percent value of acceptable kiln rotation speed change. Current revolution time is compared to the average revolution time measured from N last revolutions, where N is the Aggregate rotations parameter. If rotation speed change is too big, tire slip value is not updated.

Alarm if tire slip is not updated: because of changing kiln rotation speed current tire slip value can stay without updates for long time. This parameter allows to generate ring alarm if its tire slip value was not updated for too long.

False ring sensor signals

False ring sensor signals are filtered using the same method as the kiln trigger signal is filtered. The same setting in Linescano.ini are applied to both kiln trigger and ring sensor signals. Please see False kiln trigger signals description for details.

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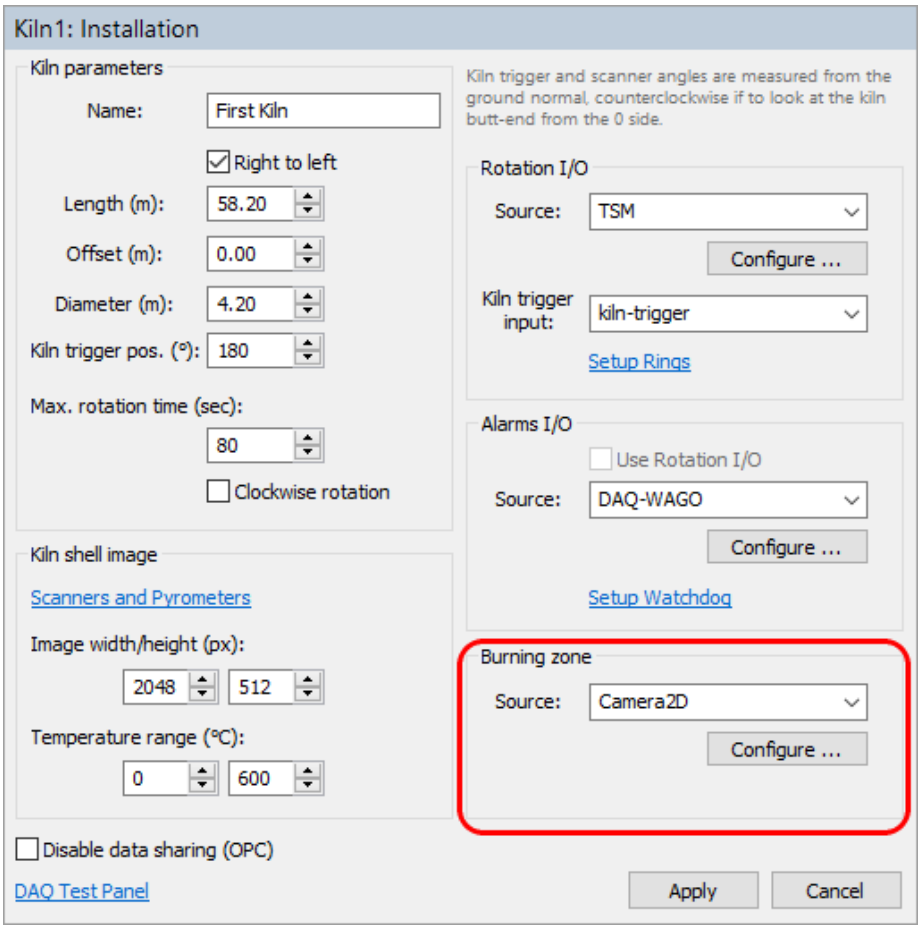
2.17. Burning zone monitoring

To setup burning zone monitoring you only need to define the device that is looking into the burning zone and measures its temperature. This device can be a pyrometer (with or without video camera) or an IR camera.

> There are no burning zone temperature alarms. Burning zone temperature is only shown on the screen.
>
> Burning zone monitoring device internal temperature (Instrument temperature) is checked in the same way as the internal temperature of the other devices.

Configuration is done on the Installation page:



You need to select the source: Camera2D or Pyrometer and then define the communication parameters.

See Camera2D and Pyrometer topics.

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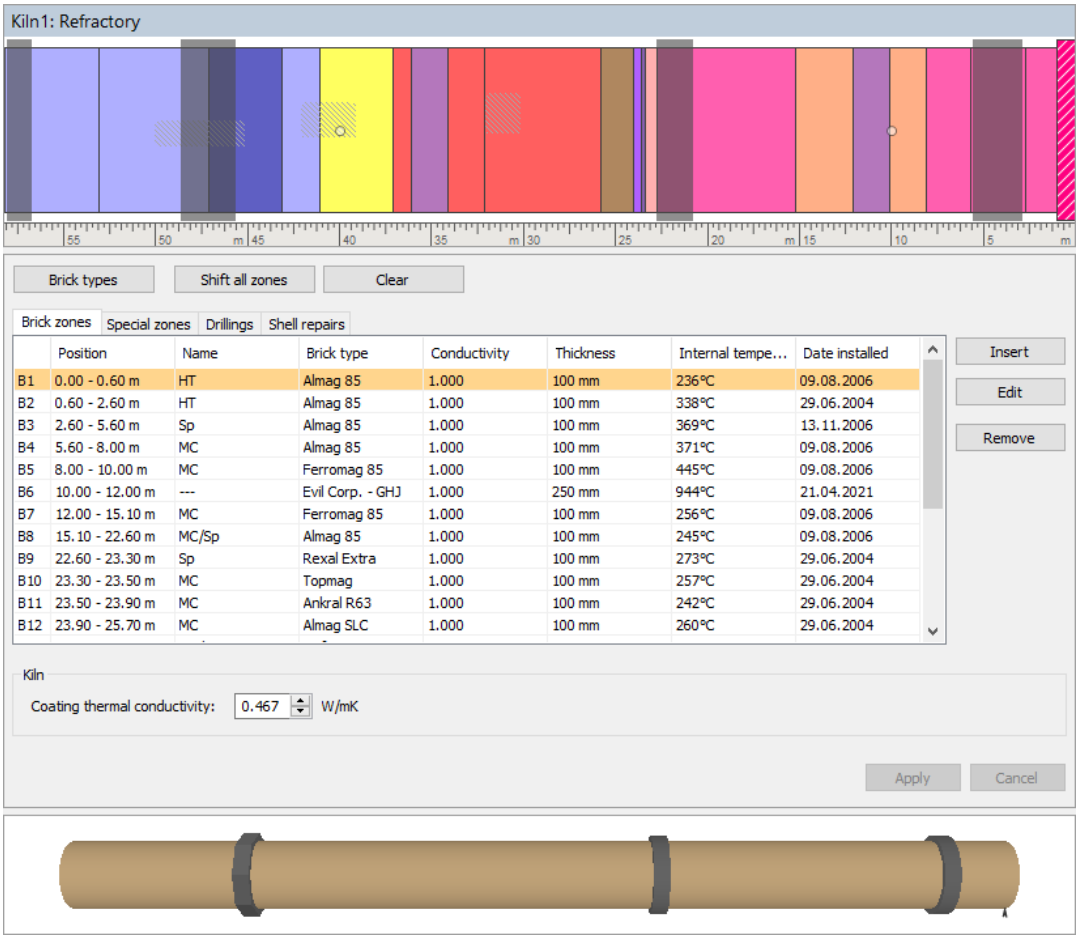
2.18. Kiln refractory and special zones

Protected by Level 2 password.

Information about bricks is used to calculate brick and coating thickness during kiln monitoring. It also allows CS400 to create a graphical diagram of the kiln refractory zones. Refractory function in CS400 is designed to show only the actual state of the kiln refractory. It is operator's responsibility to keep the refractory information up-to-date.

Select **Refractory** item in the tree structure at the left part of the **Configuration** window. Before you can define refractory zones, kiln dimensions on the **Installation** page must be defined. See topic Kiln dimensions and monitoring hardware.



Brick types

Press **Brick types** button to show the list of all available brick types. This list is only for convenience, so you don't have to enter the same data several times.

Brick zones

To show the list of all brick zones, select **Brick zones** tab:

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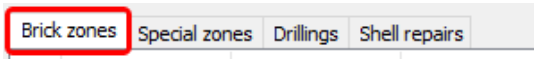
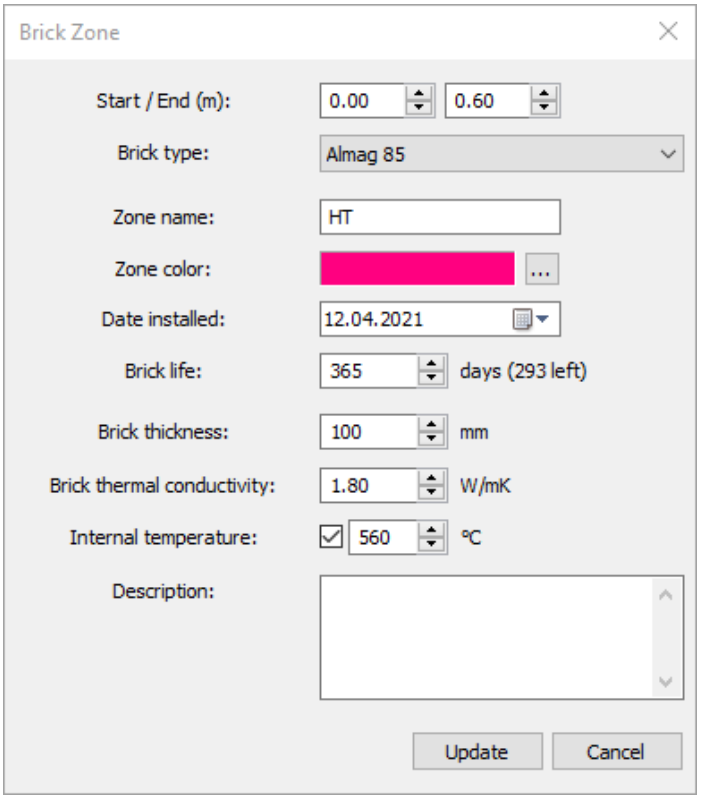


Use the **Insert** button to add new zone definitions to the kiln refractory. For every zone you can specify different parameters depicted below. To modify already existing zone, double-click on it or select it and press **Edit**. To remove a zone, mark it in the refractory window or in the list of zones and press the **Remove** button.



For a brick zone, you can specify:

- zone location (Start/End position in kiln coordinates);
- brick type
- zone name;
- color to display the zone in the kiln design view;
- date of the installation;
- brick life;
- initial brick thickness;
- brick thermal conductivity: usually ranges from 0,1 to about 10 W/mK;
- temperature inside the kiln at this zone.

You can also add any description you want.

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Note

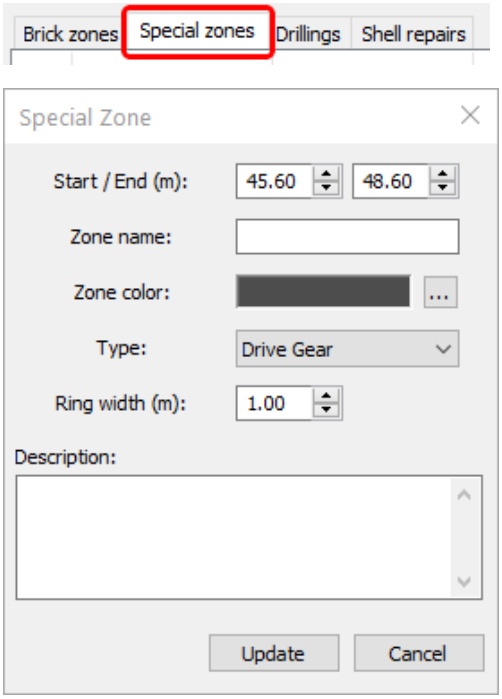
Brick conductivity, internal temperature and initial brick thickness are important for proper estimation of brick and coating thickness.

Brick life

Date installed and **Brick life** parameters are used to control typical brick duration. When bricks in one of the refractory zones reach the end of their typical life cycle, the **Refractory** alarm is generated and corresponding brick zones are marked with an exclamation mark.

Special zones

Special zones are needed to mark the areas of the kiln where brick thickness calculation is not possible because these areas are blocked from scanners and pyrometers view.



For special zones, beside location, name and color, you can define zone type ("Gear Rim", "Live Ring" or "Other") and ring width.

Zone type and ring width is used to display corresponding "ring" on the 3D kiln model. There are no 3D display for special zones with type "other".

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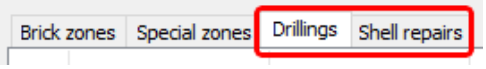
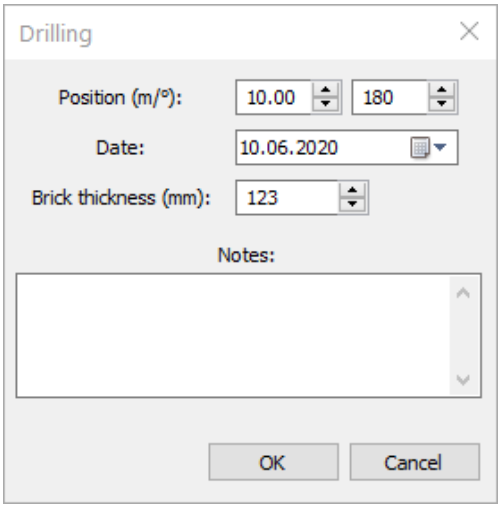
Note

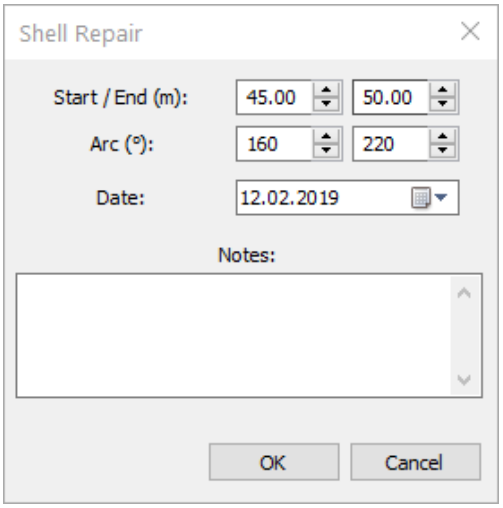
Special zones are excluded from brick and coating thickness calculation (using the Start/End position) as they do not allow scanners to measure temperature on kiln surface in these zones.

Drillings and shell repairs



These lists are used to record places of the kiln where drilling and shell repairs were made. Data from these lists does not affect system functioning.





Whole kiln related controls

Use **Shift all zones** button to shift all brick and shadow zones along the kiln right or left by a specified value. Shift value is added to start and end position of each zone. To make a left shift, enter a negative value.

Pressing **Clear** button deletes all refractory zones - brick zones, special zones, drillings and shell repairs.

At the bottom of the window, you can set **Coating thermal conductivity** used for calculation of coating thickness. (Clinker conductivity is about 0.467 W/mK for 0-700°C, and it increases above 700°C). The same value is used at any part of the kiln.

2.19. Alarms

Protected by Level 1 password.

Alarm conditions can be defined for different kiln parts. When an alarm condition is met alarm is displayed on the monitoring screen and also can be reported to an external expert system with the help of external outputs (Alarms I/O).

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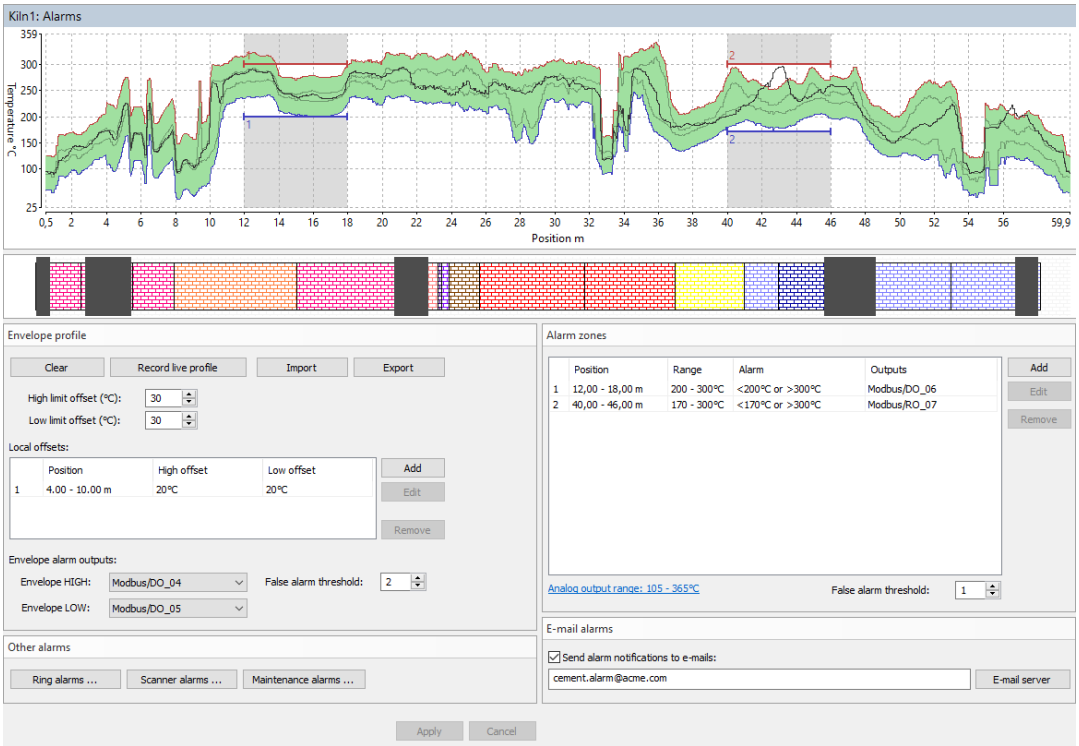
To configure alarm conditions select **Alarms** item in the tree structure at the left part of the **Configuration** window. Before you can define alarms, **Installation** part of the configuration must be ready and working, you should have access to the scanned data and to the alarms I/O device. See topic Kiln dimensions and monitoring hardware for details.



Envelope profile alarms

Kiln envelope profile can be used to define permissible temperature range for every position along the kiln. The main idea behind it is to record kiln shell temperatures when the kiln is in a good condition, and then check that the temperature at each position does not differ too much from the original good value. When the difference is too big, **Envelope alarm** is generated.

There are several ways to define the envelope profile:

1. Record current kiln temperatures: press **Record live profile** button, the live profile will start forming the envelope profile. Press the same button again (then it is called **Stop live profile**) to stop forming the envelope profile.
2. Import from a previously stored infrared image of the kiln shell: press **Import** button and select a path to a previously stored infrared image of the same kiln.
3. Import from a text file: press **Import** button. In the File Open dialog, in the **Files of type** combo-box, select *Envelope files (*.txt)* and locate a text file with envelope values.

To define how much temperatures of the kiln are allowed to differ from the recorded envelope use **High limit offset** and **Low limit offset** fields. Two gray lines on the envelope graph shows the initial envelope - the envelope without offsets.

You can also add offsets to the envelope locally. Use **Local offsets** list for that.

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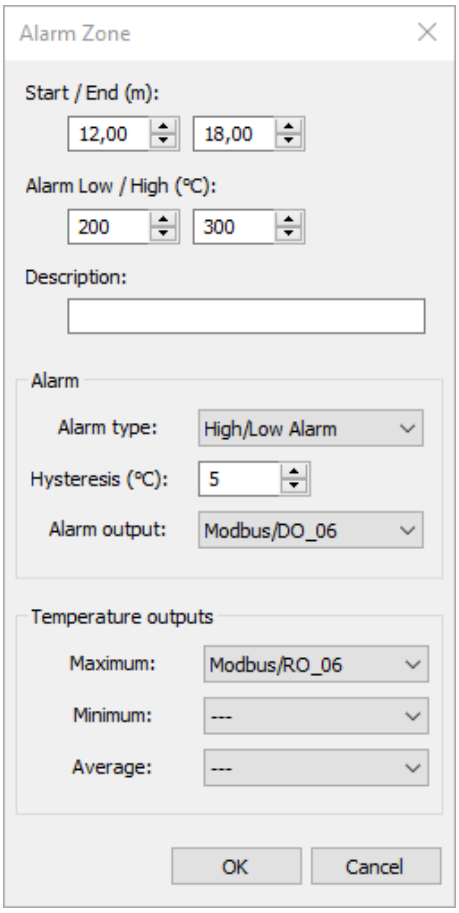
Envelope alarm outputs: when measured kiln temperature at some point goes outside the limits defined by the envelope profile, an alarm is generated. **Envelope HIGH** is generated when the upper limit is passed, **Envelope LOW** - the lower limit. You can select external outputs that will be triggered when the alarm is active.

False alarm threshold: indicates for how many kiln revolutions the alarm condition should be met to trigger an alarm.

Alarm zones



You can define a temperature limit that should not be exceeded at some particular part of the kiln. You can define both upper and lower limits.

When the limit is exceeded, an alarm signal is triggered. This signal can be forwarded to an external output. The alarm message will also appear on the computer screen.

To add an alarm zone press the **Add** button in the **Alarm zones** frame. An alarm zone is defined by the following parameters:

- **Start / End**: start and end positions along the kiln axis.
- **Alarm Low / High**: lower and upper limits to trigger an alarm.
- **Alarm type**: can be "High/Low alarm", "High alarm", "Low alarm" or "Off".
- **Hysteresis**: hysteresis to prevent alarm from turning off too quickly.
- **Alarm output**: name of the external output for the alarm signal. It can also be the beeper or no output.
- **Temperature outputs**: alarm zone maximum, minimum and average values can drive analog outputs.

Alarm zones are marked on the diagram with red and blue horizontal lines and zone numbers.

Note

If you specify a new zone which overlaps previously defined zones, the existing zones will be sized or deleted to free space for the new zone.

To define an alarm zone that corresponds to a brick zone, double-click on the brick zone in the refractory view window.

Analog output range: for 4..20 mA analog outputs defines which temperature value corresponds to 4 mA and temperature value that corresponds to 20 mA. Similar for VDC analog modules. For digital interfaces like Modbus these values can be setup but are not used.

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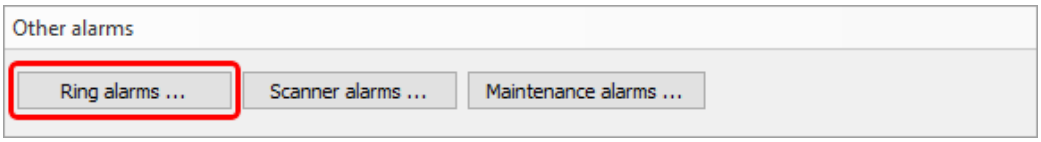
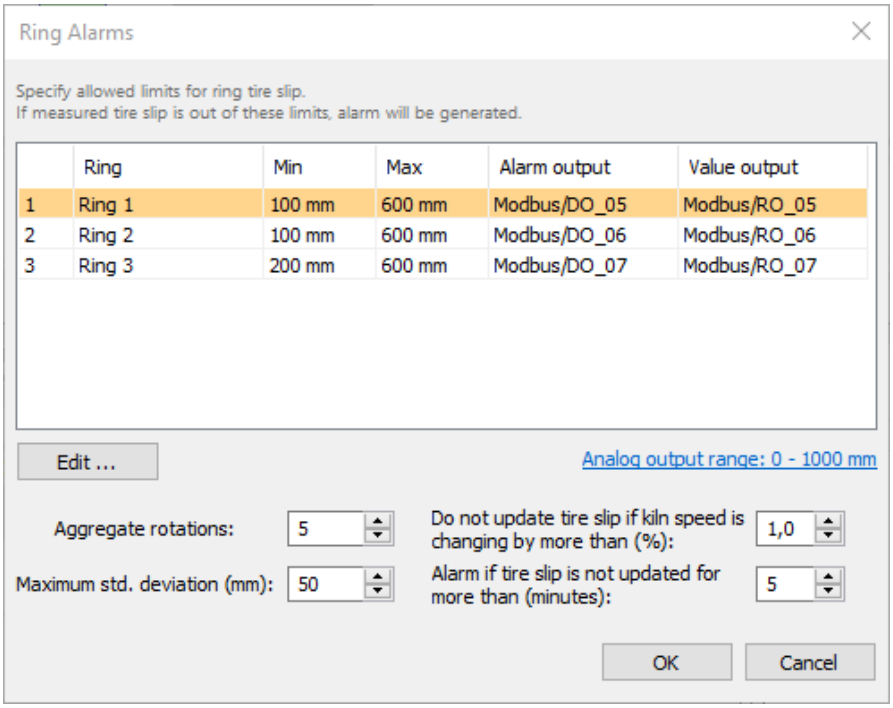
Ring alarms

Ring alarm is an alarm that informs that something is wrong with a kiln external ring. Ring alarm is generated when measured tire slip value for a ring goes out of defined limits or a problem with the revolution sensor is detected and there are no changes registered in the kiln rotation speed that could influence tire slip measurement.



Rings and corresponding revolution sensors are defined on the Installation page. Here you define permissible tire slip limits, tire slip calculation parameters and hardware outputs.



To learn what **Aggregate rotations**, **Maximum std. deviation** and other parameters mean please see Tire slip monitoring topic.

Double click on a ring to change alarm settings for this ring:

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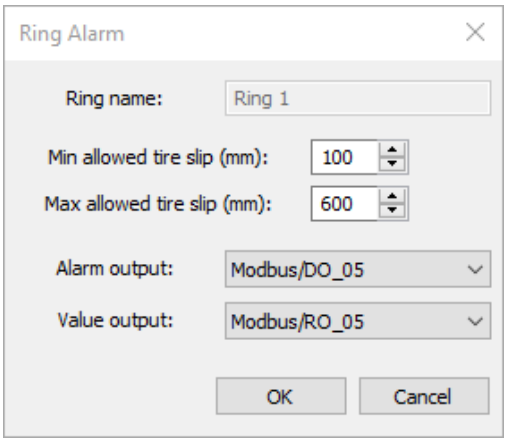


Minimum allowed tire slip: if measured tire slip value is smaller than this value alarm is generated.

Maximum allowed tire slip: if measured tire slip value is larger than this value alarm is generated.

Alarm output: discrete output that is set to 1 when alarm related to this ring is detected.

Value output: analog output which value is changed according to the measured tire slip value.

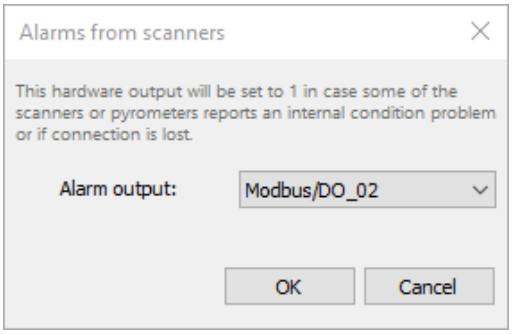
Analog output range: defines what temperature value corresponds to the lowest output signal value and what temperature to the highest.

Scanner alarms

Scanner alarm is triggered when there is a problem with a scanner or with a pyrometer.

Causes for the alarm are:

- Connection lost, data from a scanner or pyrometer stop coming.
- Scanner or pyrometer internal temperature is higher than the defined limit.
- Scanner or pyrometer reported an error state.



You can assign an output for this alarm.

Maintenance alarms

Purpose of a maintenance alarm is to remind that it is time to inspect the hardware - check that everything is fine, clean the lenses and so on.

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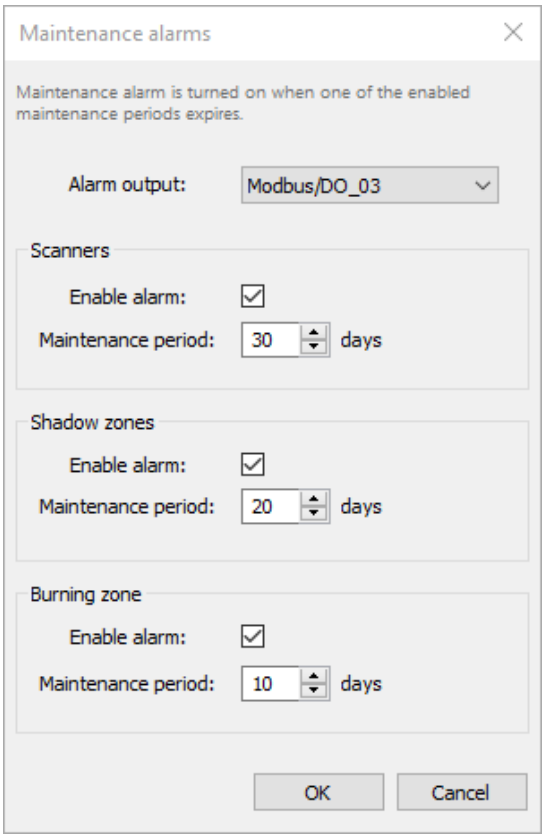
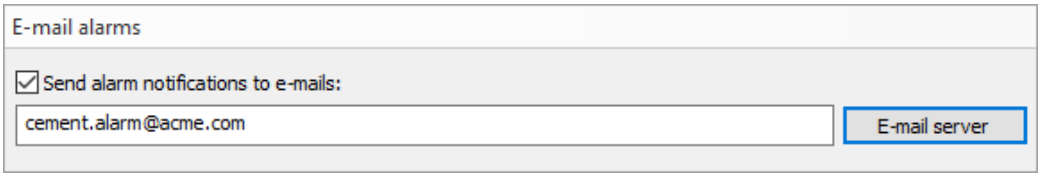
There are three groups: scanners, shadows zones (pyrometers) and burning zone. Each group has its own period.



E-mail alarms

It is possible to configure CS400 to send notification e-mails in case of alarms. The e-mail is sent when active alarm list is changing.



E-mail server

In order to send e-mails, CS400 needs access to an e-mail server that will handle e-mail delivery. To configure server settings press **E-mail server** button.

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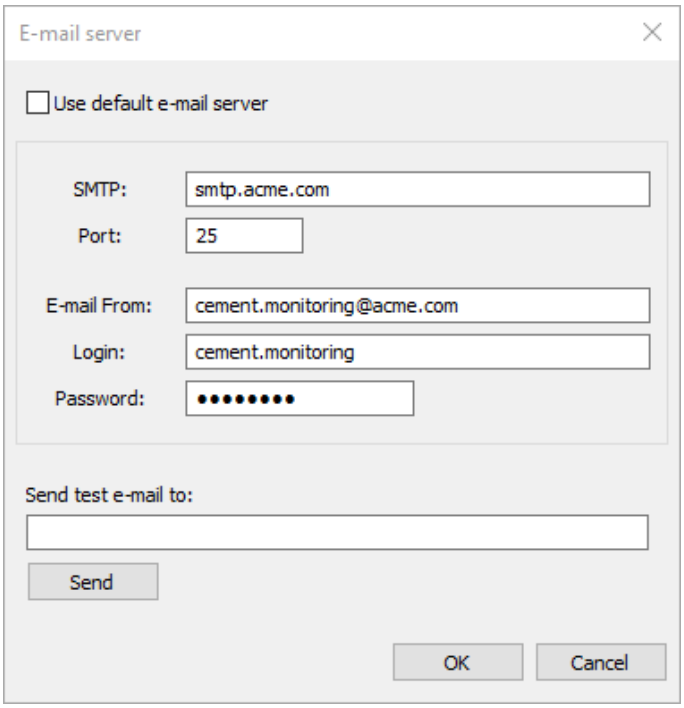

SMTP: address of the e-mail server.

Port: port to use to send e-mail messages to the server.

E-mail From: source e-mail address (alarm notifications will be coming from this address).

Login: login required to sign in to the e-mail server.

Password: password required to sign in to the e-mail server.

Testing that e-mail server is configured properly

To test that e-mail server configuration is correct, try to send a test e-mail to any address of yours. Type the address in the **Send test e-mail to** field and press **Send** button.

2.20. History storage

Protected by Level 1 password.

History storage folder

Use **Common Kiln Settings** dialog to see where history data is stored. To open the dialog click on **Common Settings** in the kiln tree at the left part of the **Configuration** window.

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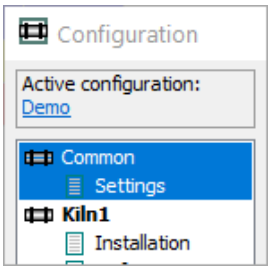

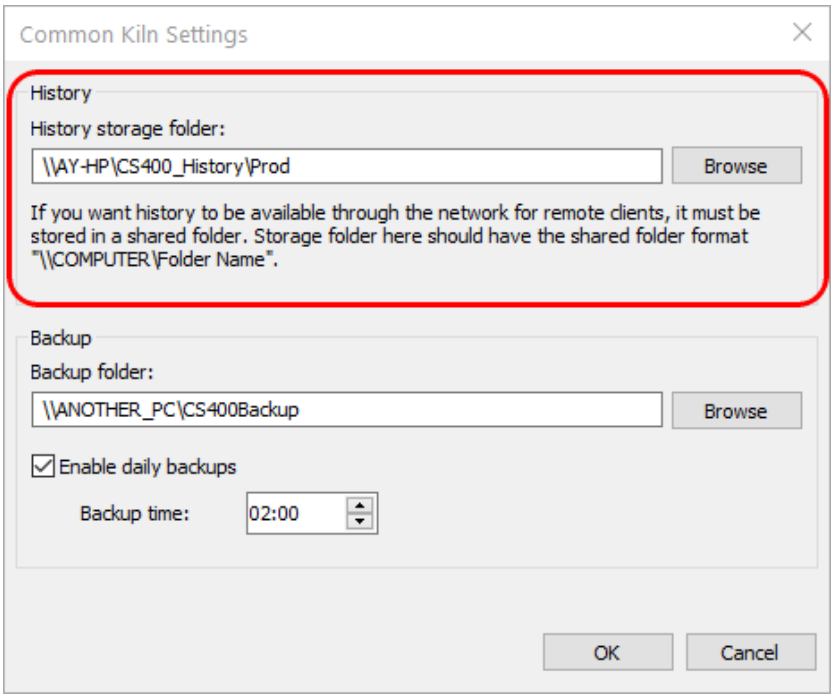

It is not recommended to change the storage folder. If you do need to change it, please make sure that your new folder is accessible from the network and has the shared folder format.

Default history storage folder is shared automatically during system installation.

Click **Browse** to select the folder where the history database will be stored.

In order to give access to the history data to CS400 clients the history storage folder must be accessible by other computers in the network using the same path. To make it possible, the folder path must have the shared folder format ("\\COMPUTER\Folder"), otherwise clients in the network will not be able to load history data.

History will be saved in a sub-folder named "KilnN". If you have two and more kilns monitored on one server, they all will use the same storage folder. For example, if you define storage folder for to be "\\AY-HP\KilnHistory", kiln data will be saved to "\\AY-HP\KilnHistory\Kiln1". Second kiln's data will be saved in \\AY-HP\KilnHistory\Kiln2" and so on.

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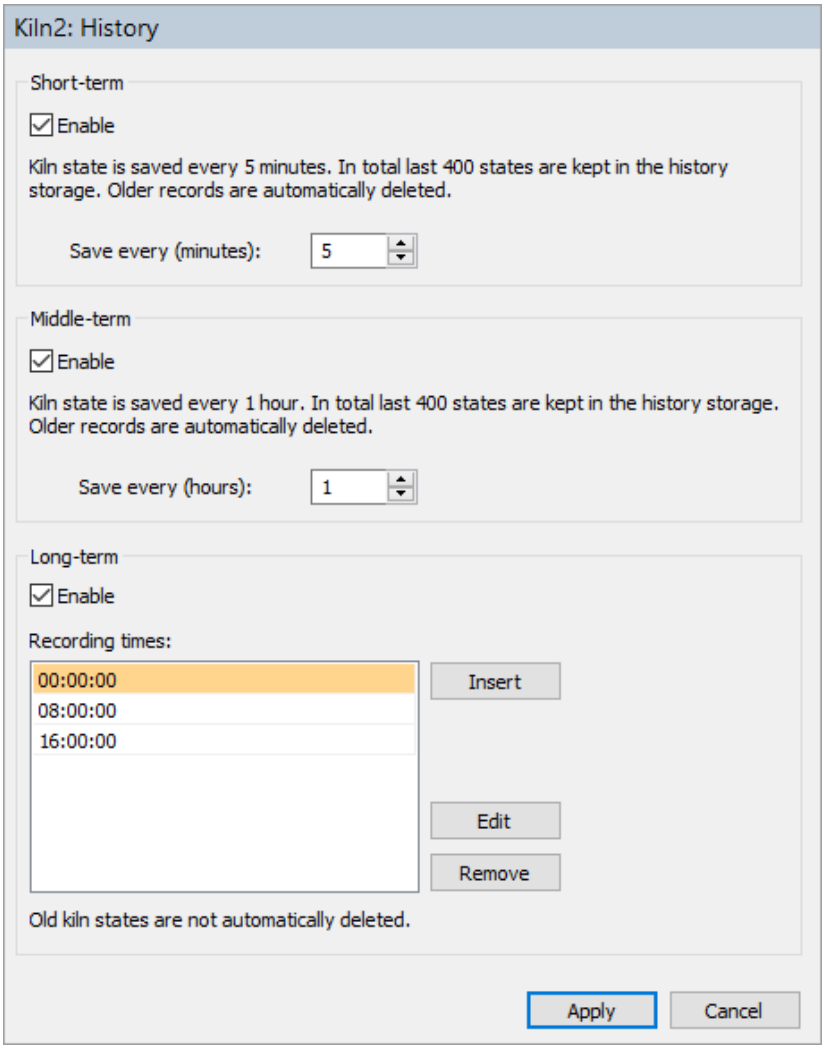
History storage periods

Select **History** item in the tree structure at the left part of the **Configuration** window.



Here you can specify how often kiln state data will be stored.

There are three types of history storage: short-term, middle-term and long-term.

Short-term

Short-term history is designed to save kiln state every 5 minutes (e.g. 14:00, 14:05, 14:10, and so on). Only 400 latest states are stored, older records are automatically deleted. You can change the 5 minutes period.

Enable short-term history by placing a marking **Enable** check box.

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Middle-term

Middle-term history keeps kiln states recorded every hour (e.g. 00:00, 01:00, 02:00, ...). In this case also no more than 400 latest states are stored. Older records are automatically deleted. You can increase the one hour period.

Long-term

Long-term history is different:

- The data is never deleted, the entire history is always available.
- Record times are selectable. You decide by yourself when, at what time every day kiln state data will be recorded.

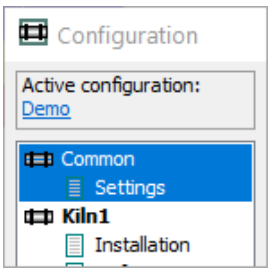
Press the **Insert** button to add a new recording time. You can also edit or remove already existing time by clicking on it and pressing the appropriate button.

It is also possible to make an unscheduled recording of the actual kiln state (main menu **Extras / Save Kiln State to History** in the Monitoring window).

2.21. System backup and recovery

Enabling backups

To enable backups, you must specify the location where the backup data will be stored. This is done in the **Common Kiln Settings** dialog. To open the dialog click on **Common Settings** in the kiln tree at the left part of the **Configuration** window.



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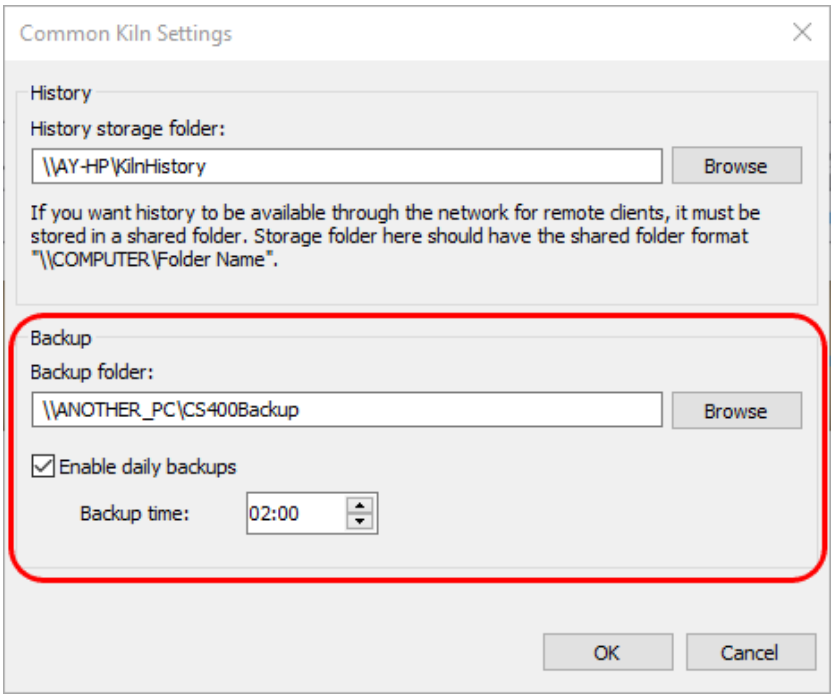

The backup folder must be located on another physical drive on the same computer, or, better, on another computer in the network. This will allow to restore system configuration and historical data in case of a PC hardware breakdown.

It is recommended to enable daily backups, otherwise operator will need to start backups manually. Backup process does not influence kiln monitoring, it is run in a separate process.

Data to be backed up

Backed up data includes:

1. Complete system configuration (includes configuration of the monitoring hardware, the refractory, the alarms and the history storage settings);
2. Kiln history;
3. Rotation / Tire slip history;
4. Burning zone history.

Configurations are backed up incrementally. This means you can revert not only to the last backed up configuration, but also to an older configuration.

All other data (kiln history, etc.) is just mirrored, an exact copy of the data is maintained in the backup folder.

Checking backup status and starting backup manually

Backup status is displayed on the start-up screen. To show the start-up screen, close all monitoring windows (this will not stop monitoring).

Information about backups is displayed under the list of kilns. There you can see if the daily backups are enabled, time and result of the last backup and also next planned backup time.

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Active configuration: Demo

First Kiln	Running	ALARM	
localhost/First Kiln	Running	ALARM	

Last backup: Today 08:28:56 Completed successfully.
Next auto backup: 13 Jun 03:00:00

Backup log

Run backup now

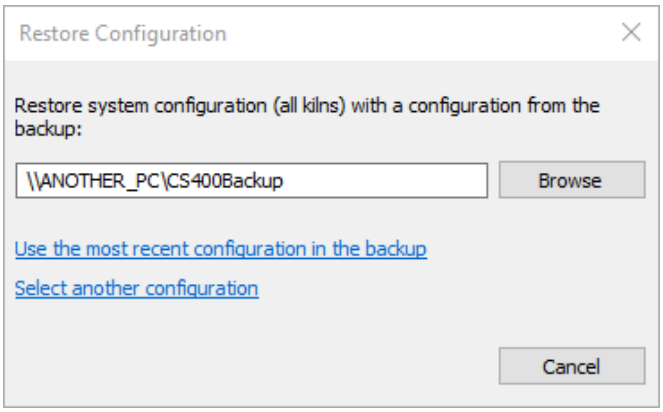
If the last backup did not complete successfully, the reason can be found in the backup log. Click **Backup log** link to see the log file.

Click **Run backup now** to start the backup manually. This link should be used to do backups if automatic backups are not enabled.

Restoring system configuration

To recover system configuration:

1. Close all monitoring windows to show the start-up screen.
2. In the main menu select **System / Restore Configuration**.



3. If you want to use another backup folder, not the currently configured one, press **Browse** and select the other backup folder.
4. Clicking **Use the most recent configuration in the backup** will use the last available configuration.
5. If you want to revert to an older configuration, click **Select another configuration** and choose the needed folder by date.

Restoring historical data

To recover history data:

1. Close all monitoring windows to show the start-up screen.
2. In the main menu select **System / Restore History**.

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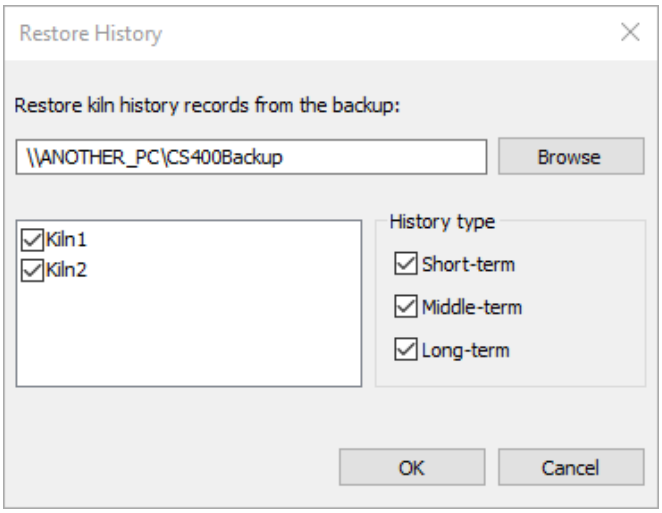

3. If you want to use another backup folder, not the currently configured one, press **Browse** and select the other backup folder.
4. Select kilns you want to restore history data for and also history types that you want to restore.
5. Press **OK** to begin copying data from the backup.

Attention

During recovering from a backup, the current configuration (if the configuration is being recovered) and the existing history data (if the history is being recovered) will be permanently deleted, overwritten with the data from the backup.

2.22. OPC UA configuration

OPC UA does not require any configuration.

2.23. OPC Classic configuration

Important

OPC will not work if CS400 server is started in a Remote Desktop session. Please do not use Remote Desktop to configure and run CS400 server, use other alternatives like VNC.

OPC Core Installation

CS400 uses OPC version 2.0. OPC Core components are installed together with the main application, so there is no need to install them separately.

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Configuration summary

To setup OPC on the computer you should do the following:

1. Server and client: Run CS400 as administrator to allow it to register itself in Windows Firewall.
2. Server and client: Add *Remote Access* Permission for *ANONYMOUS LOGON* user in "DCOM Default Access Permissions Limits" dialog.
3. Server and client: Add *Remote Launch* and *Remote Activation* Permissions for the *Everyone* user in "DCOM Default Launch and Activation Permission Limits" dialog.
4. Server only: Add *Remote Launch* and *Remote Activation* Permissions for the *Everyone* user for **Linescano** application.

Below these steps are described in details. Pay attention to the screen shots.

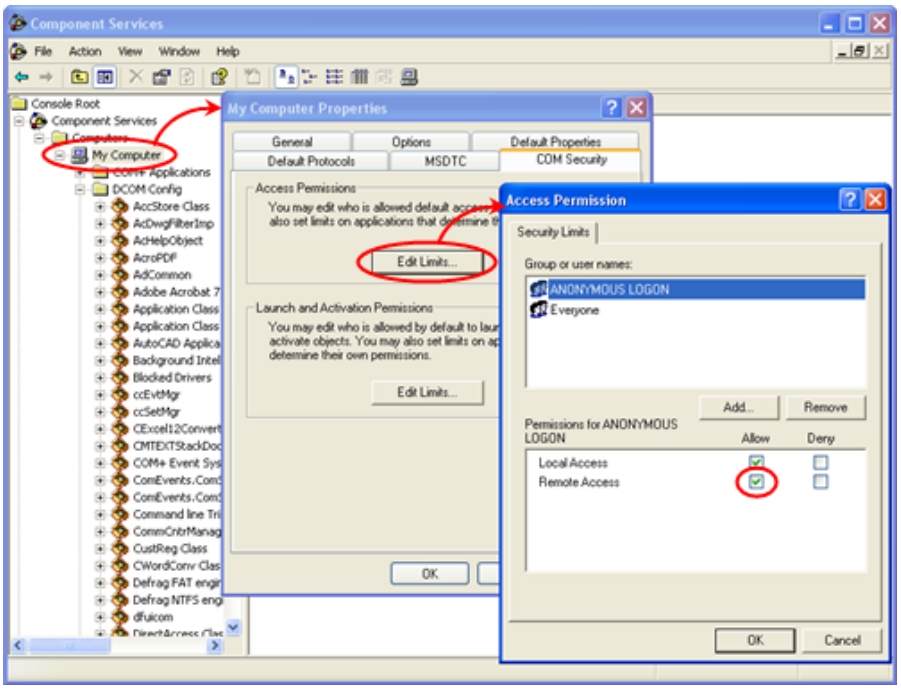
Windows firewall configuration (server and client)

CS400 automatically configures Windows firewall when its is started with Administrative privileges. This happens automatically after the installation. The user might not allow the program to run with administrative privileges after the installation. In this case program will not have the opportunity to register itself in Windows firewall. To fix this problem, just run CS400 once "As Administrator".

DCOM configuration, global limits settings (server and client)

Click Windows **Start** button, then select **Run**. Start "**dcomcnfg.exe**" and perform the following actions.

1. On the client and server computers make sure that *ANONYMOUS LOGON* user has *Remote Access* Permission in "DCOM Default Access Permissions Limits".



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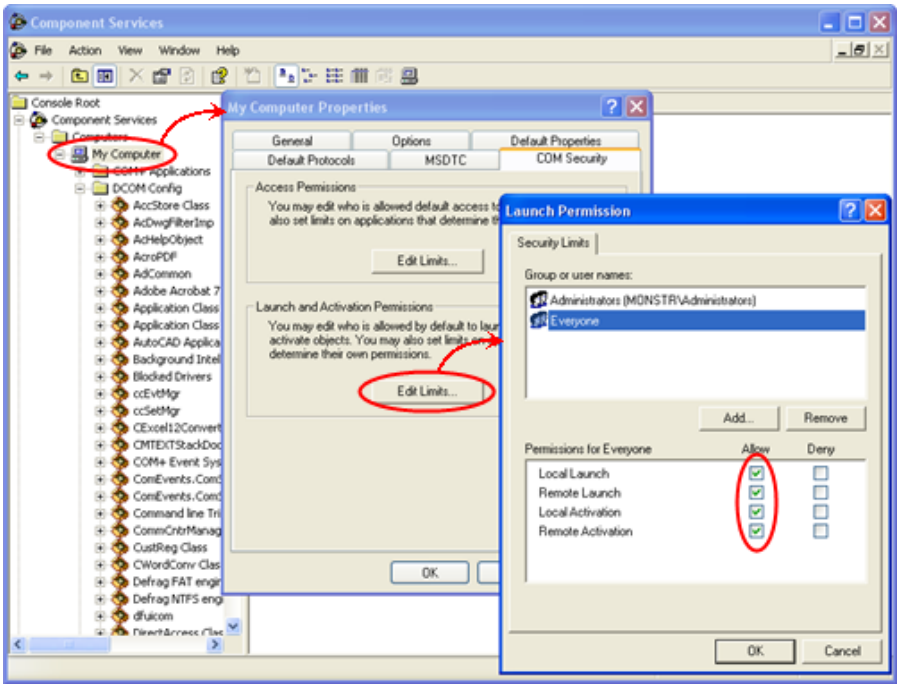
Note: this is needed only to access *OpcEnum* objects, as *OpcEnum* does not use COM-security (it uses Authentification Level: *None*).

2. On the client and server computers make sure that *Everyone* user has *Remote Launch* and *Remote Activation* Permissions in “DCOM Default Launch and Activation Permission Limits”.



DCOM configuration, Linescano OPC server settings (only server)

Click Windows **Start** button, then select **Run**. Start “**dcomcnfg.exe**” and perform the following actions.

On the server computer, find **Linescano** application and add *Remote Launch* and *Remote Activation* Permissions for the *Everyone* user.

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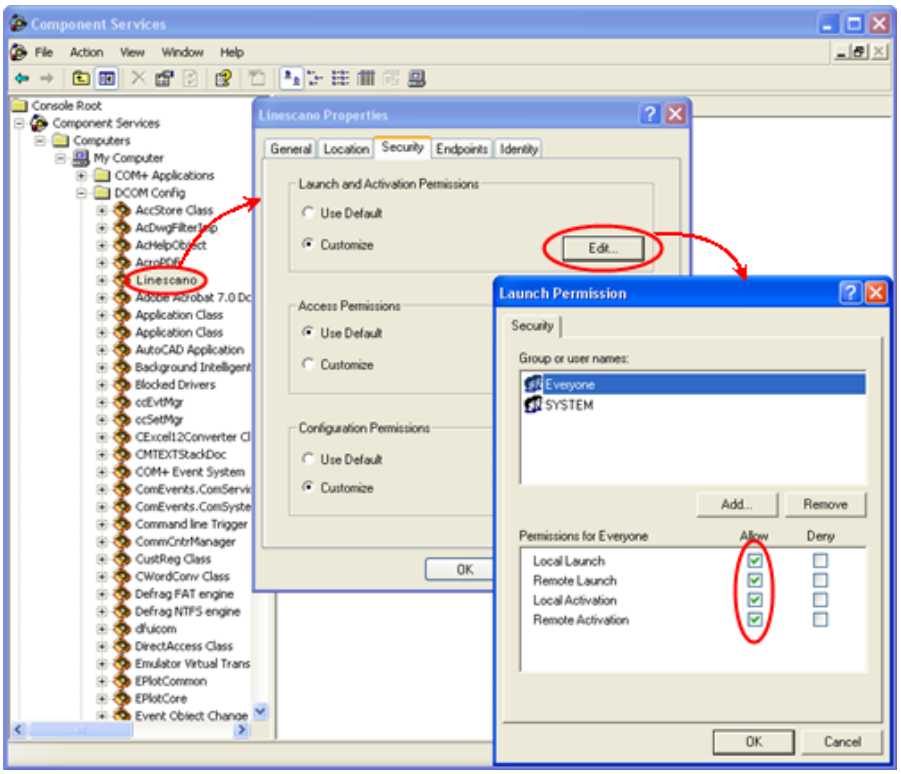

Note: you can manually specify computer users instead of specifying *Everyone*. All computer users CS400 must be specified, otherwise they will not have remote access to the OPC data.

2.24. Passwords

Access to different functions of the system can be protected by passwords. There are two access levels: **Level 1** and **Level 2**.

Without getting the appropriate password, only the read-only access is granted.

Level 1

Is required to start and to stop kiln monitoring, also it is needed to change the alarm setup and other kiln parameters which are necessary to change during the kiln run:

- Alarms including rings alarms;
- Alarm suppression;
- History storage setup;
- Inner temperature of the kiln;
- Brick thickness map.

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Level 2

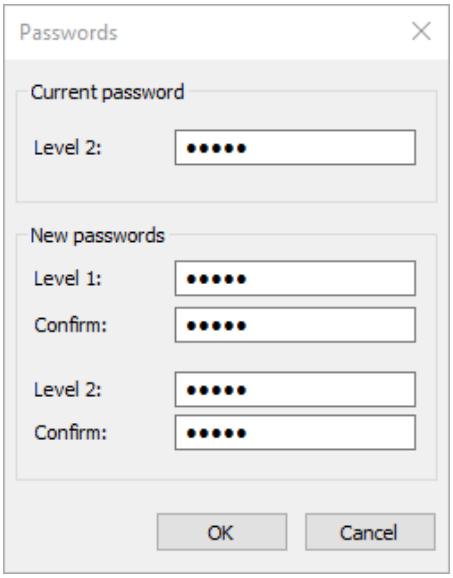
In addition to the areas accessible by Level 1 password, Level 2 password allows to modify the configuration:

- Installation;
- Refractory.

Changing passwords

To change passwords CS400 must be run with Windows administrator rights. Also you need to enter the current Level 2 password.

Close all monitoring windows to get to the Start-up screen and select **System / Change Passwords** in the main menu.



To remove password protection, use empty passwords.

Forgotten passwords

If you have forgotten your Level 2 password, you can use the **Master** password to set new passwords. Please contact your distributor to know the master password.

Configuring password protected features

It is possible to configure which functions are password protected by modifying corresponding parameters in **Linescano.ini**.

```
[PASSWORD PROTECTION]
; password will not be asked if a protected feature is accessed within
this time (seconds) after the password was entered.
password_work_time_s = 300
```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```
; configurable protected features and their password levels
temperature_scale = 1
monitoring_start = 0
monitoring_stop = 1
acknowledge_alarms = 1
```

For example, if you want CS400 to ask Level 1 password every time kiln monitoring is started, you should set **monitoring_start** parameter value to 1.

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3. Operation

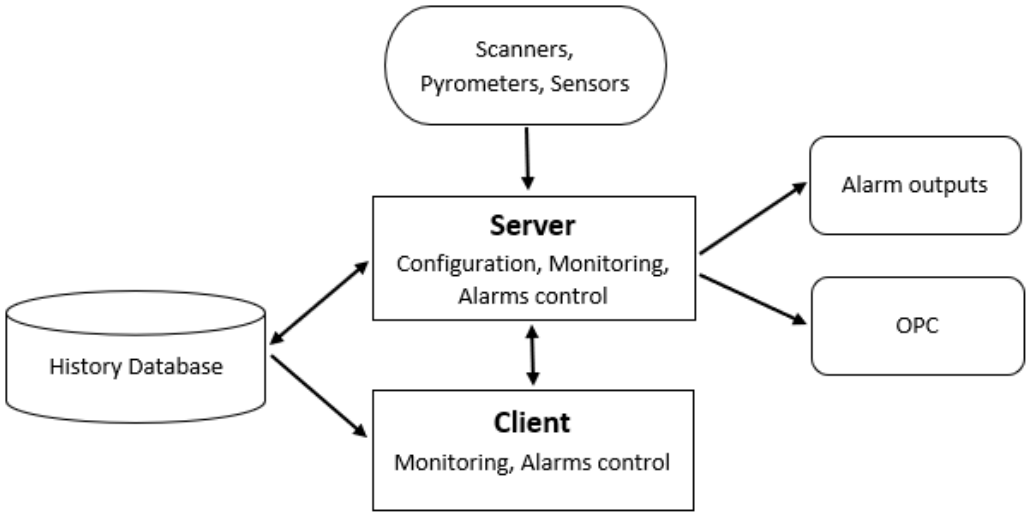
3.1. Client-server structure

The system is designed in a client-server structure. There is CS400 server that runs on a computer where monitoring instruments are connected to and CS400 client that connects to the server through a local area network and gets information about current state of the kiln.

Therefore, CS400 server runs the main system tasks, such as communicating with the temperature measuring devices (scanner, pyrometers), interpreting the incoming information, and interfacing with the digital output modules. Its other important task is serving the CS400 clients and OPC clients.

CS400 clients are designed solely for monitoring, their main duties are displaying the actual physical state of the kiln, as well as recovering historical data from the system. Furthermore, they permit the user to control the events (alarms and errors) that can show up in the system.

All monitoring functions are also present in CS400 servers.



CS400 server and CS400 client applications look pretty much the same:

- They use the same installation program. CS400 knows if it is a client or a server only by the license code used during installation.
- Program icon and program name in the system is the same - CS400.
- Both the client and the server have monitoring functionality. The difference is that a server displays kilns which data it gathers directly, while a client needs help of a server to get kiln information.
- If you have CS400 server installed on a computer, you cannot install CS400 client.

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3.2. Connecting a client to a server

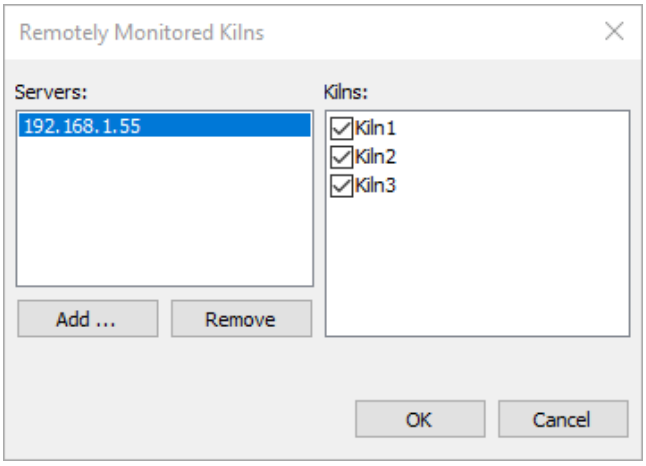
Kiln data monitored by a CS400 server is made available for other computers in the network.

Kiln monitoring server is a computer in the network which is directly linked to kiln monitoring instruments and gathers data from them.

Kiln monitoring client is a computer which connects to a kiln monitoring server and gets data from this computer and not directly from kiln monitoring instruments.

After installing CS400 client, to establish connection with a kiln monitoring server:

1. In the main menu choose **Monitoring / Remotely Monitored Kilns**. Monitoring window also has a button for this: .
2. In the **Remotely Monitored Kilns** dialog, select or add a server network name or its IP address.
3. If connection is established with the remote server and it has CS400 configured and running you will see list of kilns available for remote monitoring. Choose kilns you want to monitor by placing marks in the corresponding check boxes.



After connecting to a kiln it is added to the list of monitored kilns and you can see its state and do analysis in the monitoring window. You can see status of the connection in the status bar:

Last update time: 28.01.2021 11:16:29. Server status: Not connected.

Possible server statuses are:

- *Running*: kiln monitoring is running, connection to the server is present.
- *Stopped*: kiln monitoring is not started on the server, connection to the server is present.
- *Not connected*: no connection to the server - connection is not present and it was not possible to establish it.
- *Connection lost*: no connection to the server - connection was established but then it was lost, automatic reconnection is running, but without success.

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Note

If connection to the server is lost, CS400 client will try to automatically restore it. You are informed about lost connection by blinking kiln update time.

Changes you do on the CS400 client will not in any aspect affect the server.

Limited functionality

Functionality of the client is limited if to compare with functionality of the server:

1. You cannot start and stop monitoring.
2. You cannot save additional kiln states to the history storage.
3. You cannot change kiln configuration (also not the alarm conditions, but this is planned to be improved in next releases).

History access

Remote kilns history is available if history storage is properly configured for remote access on the server.

To view it, select necessary remote kiln in the History Tabs dialog (main menu **Monitoring / Kiln History**).

Troubleshooting

If you have problems connecting to a server you get errors in Remotely Monitored Kilns dialog. Most common reasons are:

1. CS400 server is not running.
2. If you can connect to the server but see empty list of kilns, check the data sharing is not disabled in the kiln configuration (Installation page, **Disable data sharing** check box).

3.3. Starting and stopping kiln monitoring

After configuration is done, you can start kiln monitoring. This can only be done on CS400 server.

Monitoring is stopped when CS400 server application is closed.

Start-up screen

Monitoring of all kilns start when you press **Monitor** button.

You can also start and stop monitoring using main menu **Monitoring / Start (Stop) Monitoring All Kilns**.

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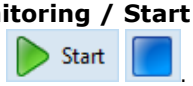
Monitoring window

When monitoring window is open, you can start and stop monitoring of the selected kiln using main menu **Monitoring / Start (Stop) Kiln Monitoring**. There are also corresponding buttons in the toolbar: 

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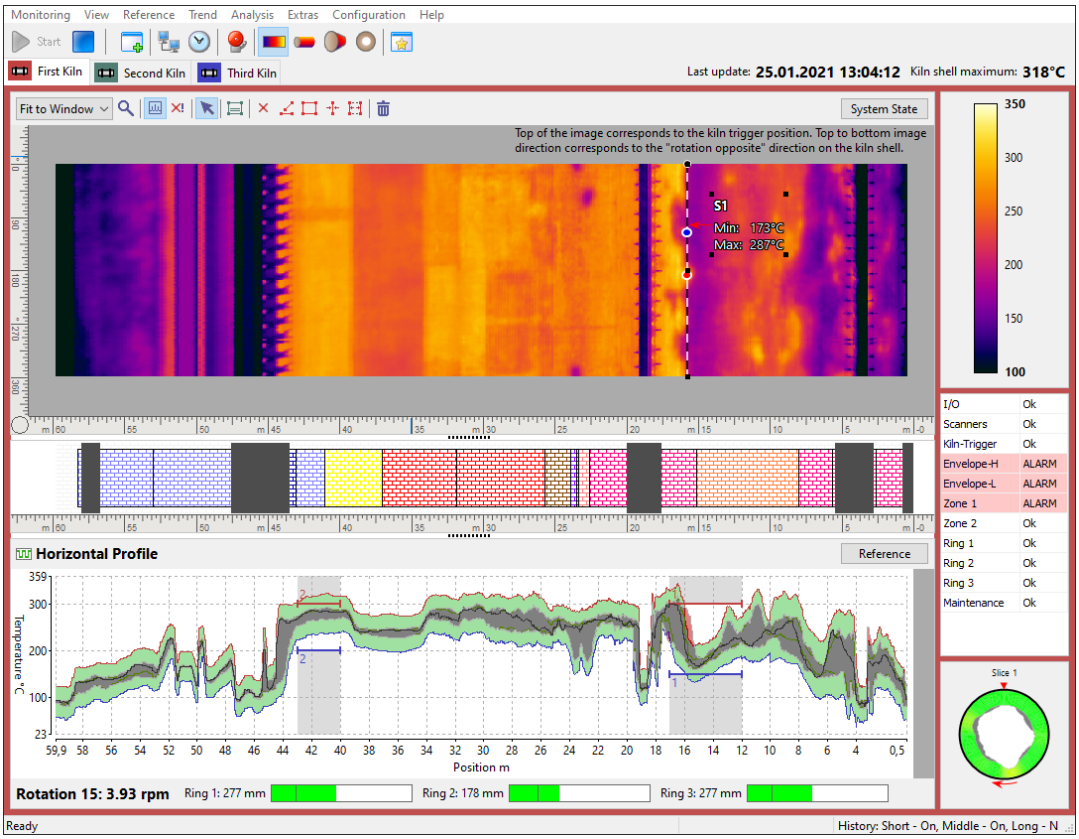
Automatically start monitoring when application starts

It is possible to configure CS400 to start monitoring of all kilns automatically when program starts. This is done in the **Settings** dialog.

3.4. Monitoring window

To open the Monitoring window from the start-up screen, press **Monitor** button or select **Monitoring / Open Monitoring Window** in the main menu (using the menu will open the monitoring window without starting kiln monitoring).



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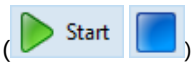
Start / Stop Kiln Monitoring

Use **Start** and **Stop** buttons in the toolbar (

) to start or stop monitoring of the selected kiln. To select a kiln, click on the corresponding tab at the top of the monitoring window.

Views

Monitoring window is divided into three parts: the main view (top), the reference view (bottom) and the side view.

Main view can display:

- Temperature map (infrared image of the kiln shell);
- 3D virtual kiln;
- 3D kiln section;
- 3D end-view.

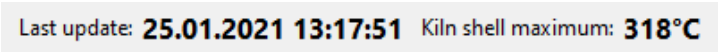
Reference view can contain:

- Horizontal profile;
- Temperature trend;
- Image trend;
- History reference.

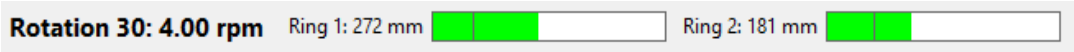
Side view displays:

- Temperature scale;
- Alarms status window;
- Burning zone view;
- Rotation / Tire slip trend;
- Thickness / Coating diagram.

Kiln state update time and the maximum kiln shell temperature is displayed in the top-right corner of the monitoring window.



At the bottom of the window, kiln rotation counter, rotation speed (rpm – rotations per minute) and tire slip information is displayed.



The main menu and the toolbar of the monitoring window is dynamic, their contents depend on the active view mode and on the type of data source (server or client).

Data sources

Monitoring window can receive the data it displays from different sources. If the screen is running on CS400 server it is getting data directly from the kiln monitoring instruments. On a CS400 client, the data is received from the server through the network. History database can also serve as a data source.

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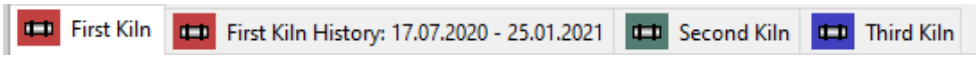
Tabs at the top of the measurement window correspond to the data sources - each data source has its own tab. There are three types of data sources:

1. **Local**: data source for a kiln monitored directly by this computer.
2. **Remote**: data source for a kiln monitored remotely by another computer in the network.
3. **History**: data source that gets data from the history database of a kiln.



- Red light on the tab informs about an alarm.
- Green means everything is OK.
- Blue light indicates a hardware breakdown. The breakdown details can be found in the System State window.

All tabs contain the name of the kiln they refer to. Besides, remotely monitored kiln tabs contain server computer name. Data from the history storage is accompanied with the time information.

Status Bar

The status bar contains specific information depending on the selected tab (e.g. next history recording time, remote server status, date and time of the current history frame, etc.).

- For local data sources the left cell of the status bar indicates whether short-term and middle-term history is on or off, and the next long-term recording time if it is enabled (see Configuring history storage).
- For history data sources the status bar shows the date and the time of the current history frame.
- For remote data sources the status bar indicates the monitoring server status (running, stopped, connection lost, server is shut down) and the last data update time.

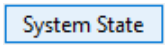
3.5. System state window

System state window displays detailed information about the kiln monitoring system and its hardware. It has several tabs. Active tab is marked by the blue color. If a tab has information about an error, this tab is marked with the red color.

Scanners and *Pyrometers* tabs are available only for the actual kiln state on CS400 server. For kiln states loaded from the history and for kiln states received remotely by CS400 clients these tabs are not available.

System state window will automatically pop out in case of a problem.

You can also open this window using main menu **View / System State** or corresponding button on the measurement screen.



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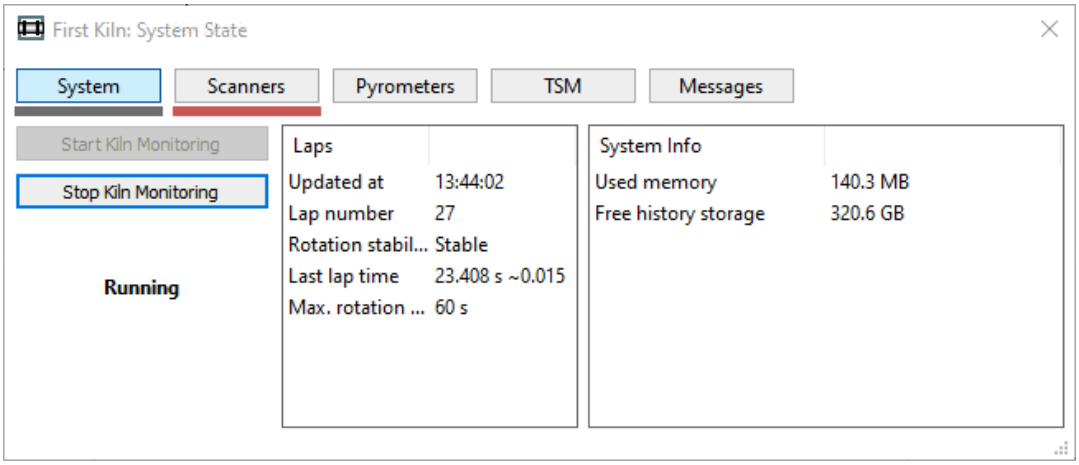
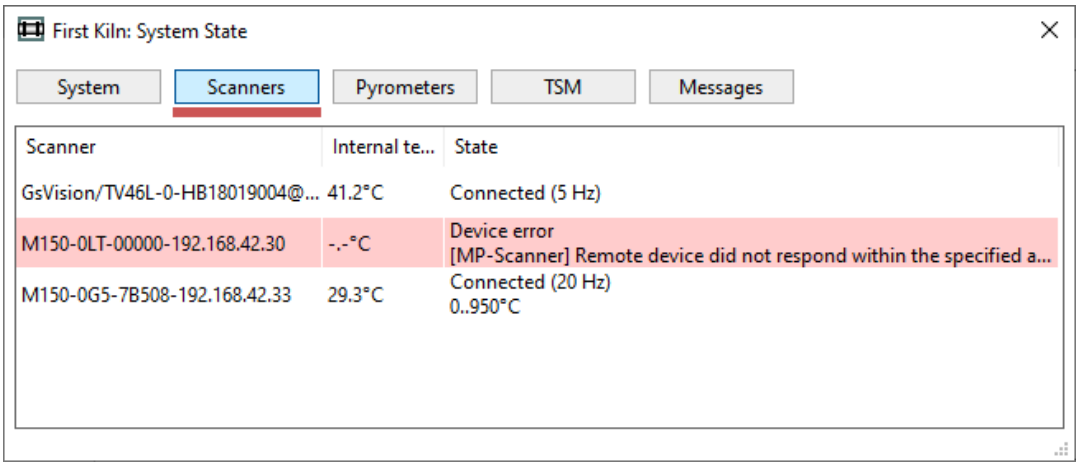
System tab



On this tab you will find the commands needed to start and stop kiln monitoring. It also shows:

- **Updated at**: the time the kiln state was updated at.
- **Lap number**: the number of laps (kiln revolutions) registered since kiln monitoring started. The number with tilde is the lap time variation measured on several recent rotations (see The kiln trigger).
- **Rotation stability**: if kiln rotation speed is stable or not.
- **Last lap time**: the time duration of the last lap.
- **Max. rotation time**: maximum expected time for one kiln revolution (from the kiln configuration).
- **Used memory**: RAM memory occupied by the program (it should stay relatively stable from the program start and day after day).
- **Free history storage**: the disk space available for history storage. If there is no disk space left, CS400 will not be able to save new kiln states to the history storage.

Scanners tab



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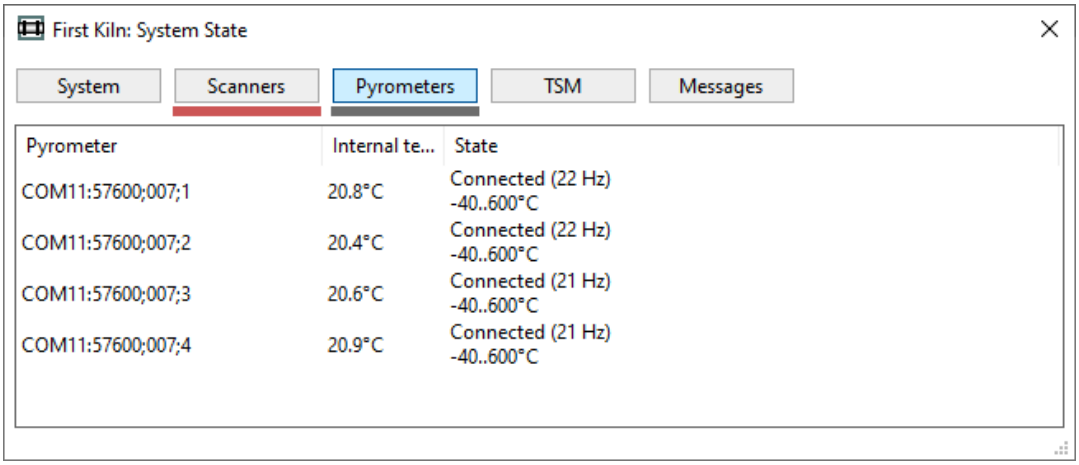
This tab shows information on the scanners configured to work with the system. This information includes device ids assigned to scanners in the configuration, internal temperature of each scanner, line scanning frequency and, in case of a problem, the problem text.

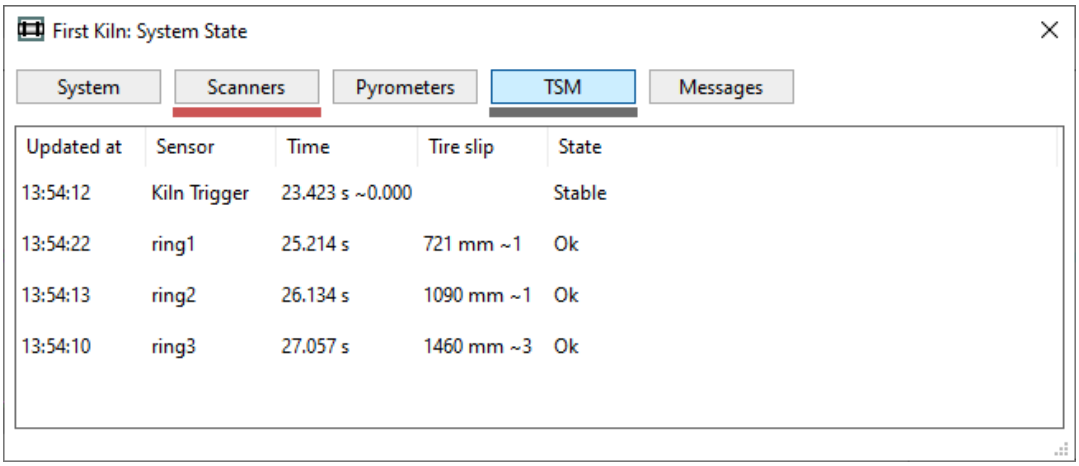
The information shown is updated every second. If communication is interrupted the information will be updated as soon as detection takes place.

Pyrometers tab



Similar as for the scanners, this tab shows information on the pyrometers configured in the system.

Tire slip monitoring tab



This tab shows information related to the TSM system (Tire Slip Monitoring).

Updated at: time when corresponding parameter was last updated. Tire slip values may not be updated after every kiln revolutions, for example, in case kiln speed is not constant. See Tire slip monitoring for details.

Sensor: name of the sensor (kiln trigger or ring name).

Time: last measured lap time (with time variation for the kiln trigger).

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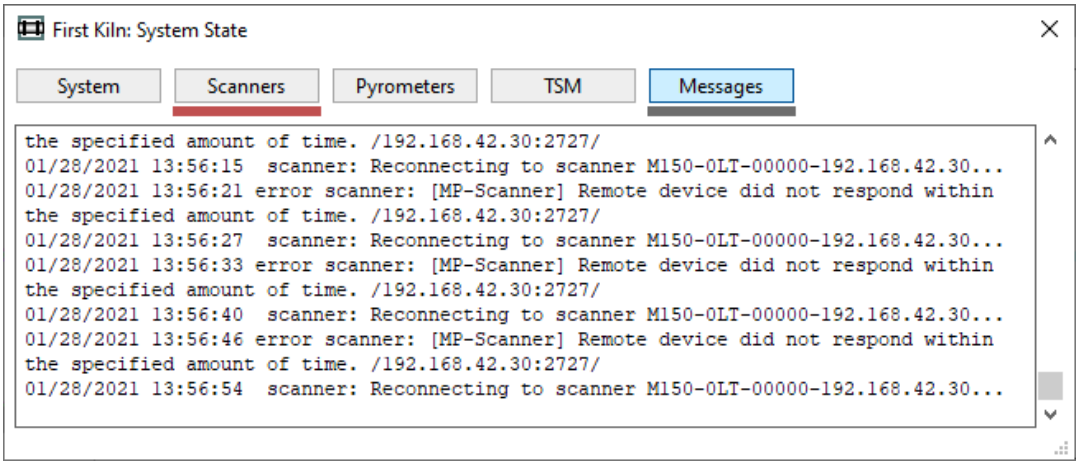
Tire slip: calculated tire slip and its variation (the number with tilde). Tire slip value is averaged from several revolutions, see Tire slip monitoring for details.

State: for kiln trigger possible states are: *Measuring rotation stability*, *Stable*, *Rotation is not stable*. For rings: *Gathering data*, *Ok*, *No signal from ring sensor*, *Update timeout*, *Non uniform*.

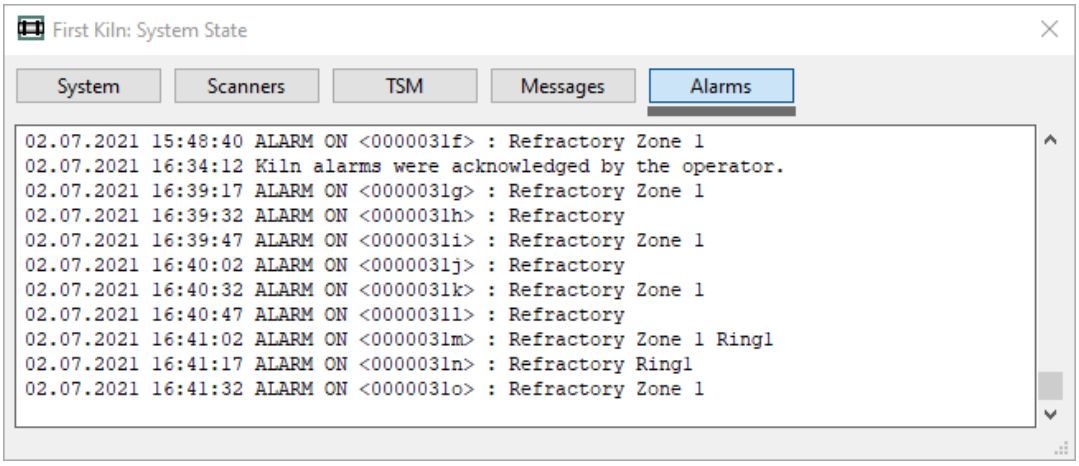
The numbers with tilde is the variation measured on several recent rotations (lap time variation for the kiln trigger and tire slip variation for rings).

Messages tab



This tab displays all messages from the system. These message can be just informative, like that monitoring was started and also messages reporting about problems. All these messages make up the events log.

Alarms tab



Show the history of alarms (alarms log).

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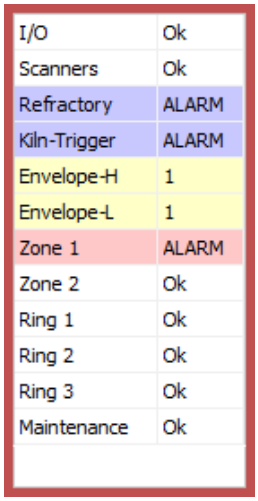
3.6. Alarms indication



I/O	Ok
Scanners	Ok
Refractory	ALARM
Kiln-Trigger	ALARM
Envelope-H	1
Envelope-L	1
Zone 1	ALARM
Zone 2	Ok
Ring 1	Ok
Ring 2	Ok
Ring 3	Ok
Maintenance	Ok

Alarms window shows all monitored alarm conditions.

- If an alarm condition is met alarm signal is triggered and the alarm condition item is marked red or blue in the list.
- The background becomes **red** for kiln state alarms and **purple blue** for hardware problem alarms.
- If the alarm condition was not met at the last revolution, alarm signal is reset and the corresponding line shows **Ok**.
- If the alarm condition was met at the last revolution but there is still the **False alarm threshold** to pass, the corresponding line becomes yellow and shows how many revolutions meeting the alarm condition are still needed to trigger the alarm signal.

To manually reset all kiln state alarms, choose **Monitoring / Reset Alarms** in the main menu.

Alarm types

I/O alarm (purple blue) informs that there is a problem with I/O (for example connection to alarms I/O device is lost).

Scanners alarm (purple blue) indicates that there is a problem with a scanner or a pyrometer (connection lost, the internal temperature is too high).

Kiln-Trigger alarm (purple blue) is generated if there is no signal from the kiln trigger sensor during the maximum kiln rotation time.

Envelope alarms (red) are generated when high or low temperature limits are surpassed. See Envelope profile alarms configuration.

Zone alarms (red) are triggered if kiln temperature passes limits defined for a zone. See Zone alarms configuration.

Ring alarms (red) are generated when measured ring tire slip value is out of the defined range, when there is no signal from the ring sensor and when measured values are nor reliable (large deviation). See Ring alarms configuration.

Maintenance alarm (purple blue) tells that it is time to check the hardware. See Maintenance alarms configuration and Resetting maintenance alarms.

Refractory alarm (purple blue) tells that bricks in one of the refractory zones have reached the end of their typical life cycle.

> **Hint**
>
> To get more information about an alarm, double click on the alarm line.

To change or define alarm conditions select **Configuration / Alarms** in the main menu or press corresponding button in the toolbar. See Alarms topic.

Kiln alarms acknowledgment

If there is an active kiln alarm, the monitoring window will show a flashing KILN ALARM message.

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KILN ALARM Acknowledge

Click on the **Acknowledge** link to stop the message flashing and make it not so alerting:

KILN ALARM History

Kiln alarm message will switch back to the flashing state if a new alarm is triggered (for example, Zone 1 alarm was acknowledged and Zone 2 alarm becomes active). An alarm turning off and then on again will also re-activate the flashing state.

If you do not acknowledge an active kiln alarm and the alarm disappears by itself (because its alarm condition is not met any more), CS400 will display the missed alarm message, which you also need to acknowledge to make it disappear.

MISSED KILN ALARM Acknowledge

Only the kiln state alarms (red) are displayed in such a manner with a possibility to acknowledge them. System alarms (purple-blue) do not require acknowledgment. When a system alarm occurs, the System State window pops up automatically and it will continue to pop up as long as the corresponding problem is not solved.

3.7. Kiln views

The upper half of the measurement window is called **Main view**. It represents the actual thermal state of the kiln shell.

There are four basic views of the kiln shell:

1. Two-dimensional infrared view (Temperature map 2D);
2. Three-dimensional view of the whole kiln in motion (Virtual kiln 3D);
3. Three-dimensional view of the kiln interior (Kiln section 3D);
4. Three-dimensional view from the kiln end (Kiln end-view).

To switch between these view modes, use appropriate toolbar buttons or commands in the **View** main menu:

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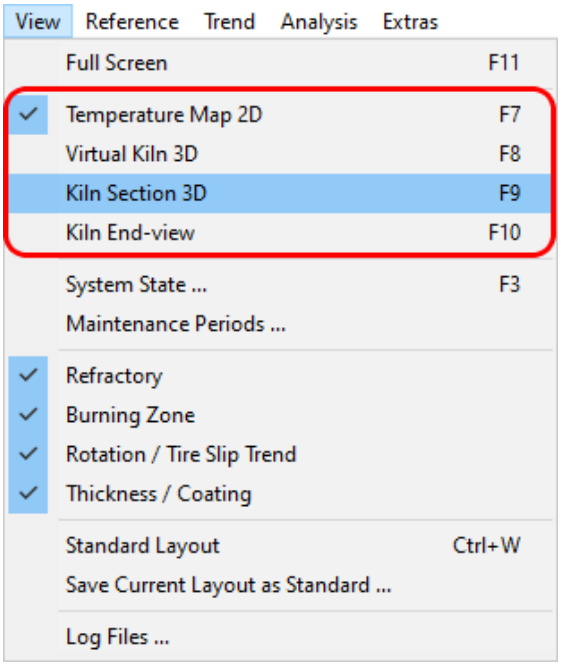


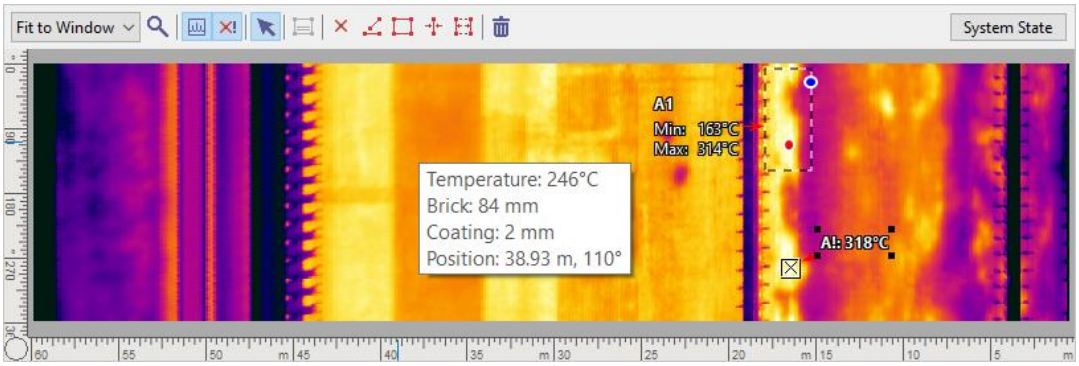
3.8. Temperature map 2D view

The Temperature Map 2D view represents a plane two-dimensional infrared image of the kiln.

The axes show the real kiln shell coordinates. The X-axis is the kiln axis; Y-axis is the angle measured in the direction opposite to the kiln rotation. 0 of the Y-axis corresponds to the kiln trigger position.

The 2D infrared image is updated after each kiln revolution.

When the mouse pointer is moved over the infrared image, an info window is displayed showing the temperature and coordinates of the spot under the pointer; brick and coating thickness values are also displayed if they are available.



The temperature Map 2D can be displayed at the top or bottom part of the screen (when combined with one of the 3D views).

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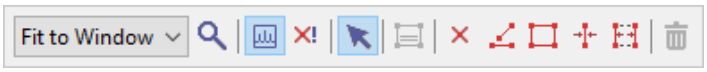
Analysis objects

The Temperature Map 2D view allows creating measurement objects on the infrared image. Here you can perform thermal analysis of the infrared image of the kiln shell: measure spot temperatures, create temperature marks, get statistical information on lines and areas, etc.

The Temperature Map 2D view has its local toolbar with all the measurement tools that can help you to analyze the infrared image:



	Zoom tool	Allows to scale the image. Pick up the zoom tool and click on any area of the image to increase it. Use the right mouse button to restore the normal image size (corresponds to Fit to Window command in the Zoom combo box). You can also use the mouse wheel to control the zoom. When the zoom factor is adjusted so that not the whole image is visible, a rectangle appears in the kiln design view showing the location of the visible area on the shell.
	Selection tool	Selects, moves and resizes analysis objects. It is also used as the flying spot temperature meter to check the temperature under the mouse pointer. With the help of the selection tool you can move and reshape objects and their labels. Hint: to switch to the Selection tool after using another tool, just right-click on the image. Double-click on any place on the image to open the brick or shadow zone information window.
	Suppress alarm tool	Allows to mark rectangular areas on the kiln shell image that will be excluded from alarm tests. See Alarms suppression topic.
	Spot tool	Creates an analysis spot object on the image. The default label of the spot object shows only the temperature at this spot. However it can also display the brick and coating thickness values at this spot. To choose which parameters to show on the label, right-click on the spot object and select Label in the context menu.
	Hot spot tool	Shows or hides the hottest spot on the kiln shell image.
	Line tool	Creates an analysis line object. You can draw a straight line in any direction (horizontal, vertical, diagonal). The line label displays maximum and minimum temperature along the line. Brick and coating thickness is not available for lines. In line's context menu you can choose to show On-Image Profile that will display the distribution of temperatures along the line.

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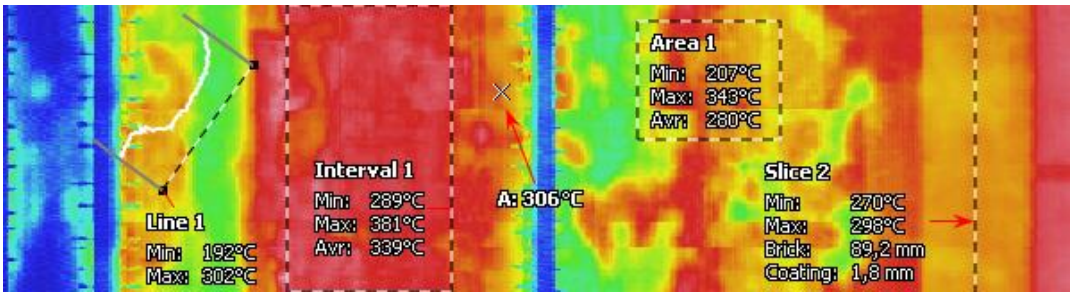
	Area tool	Creates a analysis rectangle object on the image. The default parameters of a rectangle object are the minimum and maximum kiln shell temperature in this area. Using the Label dialog the minimum brick thickness and the maximum coating thickness can be displayed as well. The area object has an additional command in its context menu - Zoom Area. This command shows image part taken by the area in a separate window with increased zoom factor.
	Slice tool	Makes a vertical slice of the kiln shell at the selected position. The slice object represents one vertical line of the image. Parameters of the slice object are the same as of area objects. In addition you can display the position of the slice in the label. As lines, slices can have on-image profile. Additional command in the context menu: Make 3D Section Here. This command opens the 3D Kiln Section view combined with the Temperature Map view, and the section position is set to the slice position.
	Interval tool	Creates an analysis interval object. The interval objects is a special case of the rectangle object, so it has the same parameter and functionality. The difference is that interval objects always cover the entire height of the image.
	Delete button	Deletes the selected object. To select an analysis object, use the selection tool. To delete all analysis objects at once, choose Analysis / Delete All Objects.

The picture below presents all the above-mentioned analysis objects.



When the Temperature Map view is activated, it is possible to perform trend monitoring of any object. See the topic Temperature Trend for details.

Objects' labels

Labels can show object properties. To see what properties are available on each type of measurement object, right-click on the object and select **Label** in the context menu. In the Label dialog you can adjust different settings for labels and add any custom text to them.

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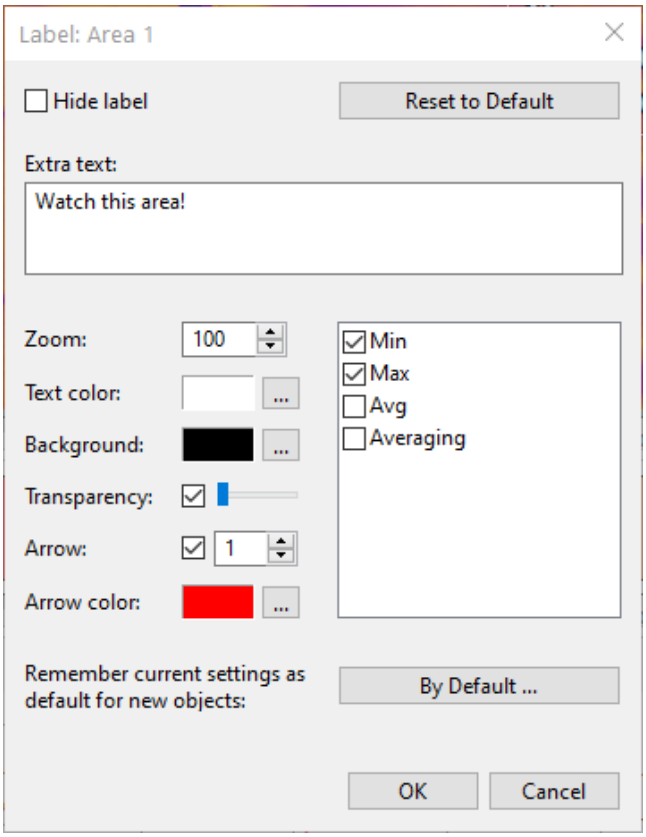

Image context menu

The infrared image of the kiln shell has its own context menu that contains all set of analysis tools described above as well as some additional commands.

- **Image Info** opens a dialog with image information such as image size, date and time image was created, calibration range. These properties are read only.
- **Zone Info** shows brick and shadow zone information for the zone at the mouse pointer position (place where you clicked with the right mouse button to display the context menu).
- **Draw Grid** shows or hides the coordinates grid on the infrared image.

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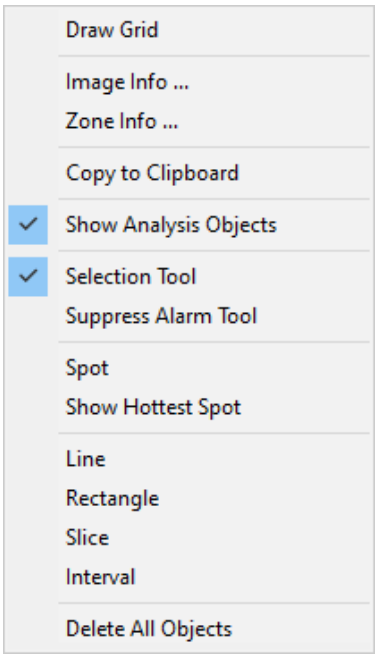

3.9. 3D kiln views

Virtual kiln 3D

This view displays the virtual kiln model in three dimensions. To switch to the Virtual Kiln 3D view, press the corresponding button in the toolbar.

The 3D virtual kiln model consist of the following parts:

- The kiln shell with infrared image on it;
- live rings and the gear rim;
- kiln trigger position marker (red triangle);
- ruler with refractory zones.

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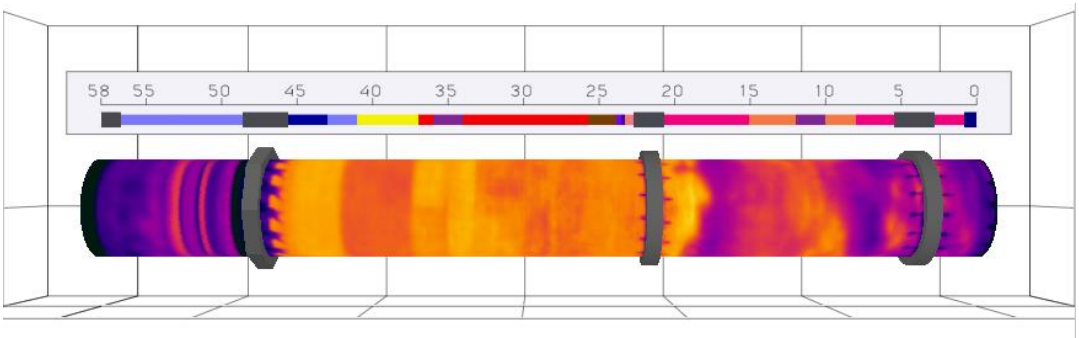

The kiln model on the screen rotates at the same speed as the real kiln. You can stop the rotation on the screen by clicking button in the local toolbar or choosing **Show Kiln Rotation** command in the 3D menu.

Virtual kiln 3D view can be combined with other views on the screen:

- combines 3D view with the Temperature map view;
- combines 3D view with the Reference view;
- 3D view is displayed full-screen.

These options are available in the local toolbar and in the **View / Windows** menu.

Adjusting the 3D scene view

The following actions can be used to arrange the scene:

1. Mouse move when the left button is pressed (by default) rotates the scene. The kiln will turn in the indicated direction so that you could see it from other angles.
2. Mouse wheel (scrolling) changes the zoom moving the kiln model nearer or farther.
3. Mouse move when the middle button (wheel) is pressed moves scene right/left, up/down over the screen.
4. Double-click with the left mouse button resets the scene – returns the scene to the default position after you have rotated, moved or zoomed the model.

However the left button action can be changed: to rotate, to move or to zoom the scene. This is useful when your mouse does not have the wheel. To change the left button action, use the **3D** main menu or the context menu.

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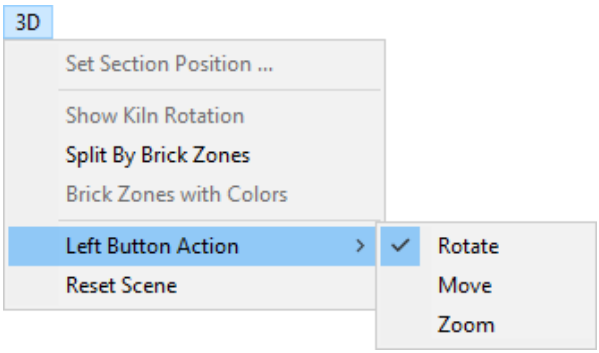
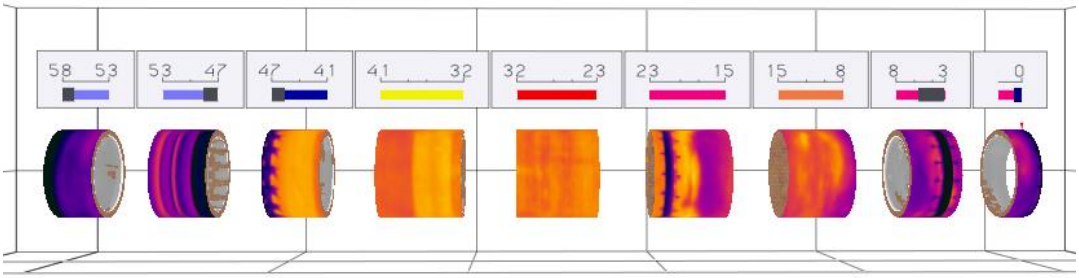


Split by brick zones

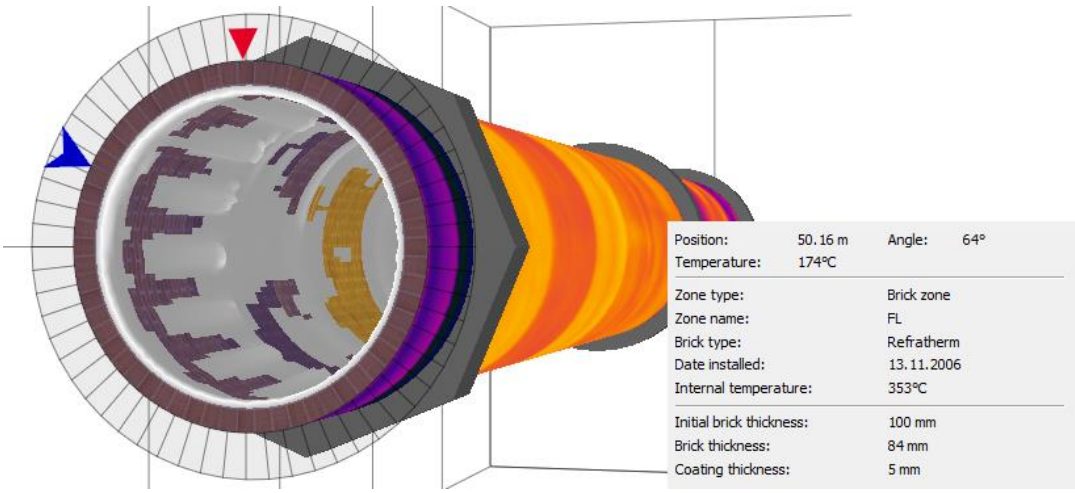
Virtual Kiln 3D view has an additional display mode: **Split by Brick Zones**. In this case the kiln (static or in motion) is cut into pieces according to the brick refractory zones (shadow zones are hidden). To return to the whole view, push the same button again.



Split by Brick Zones view makes differences between the brick zones more obvious.

Kiln section 3D view

Kiln Section 3D View virtually cuts the kiln at some position. So it shows more the kiln interior (bricks and coating), while the Virtual Kiln 3D view is more suitable for observing kiln's surface.



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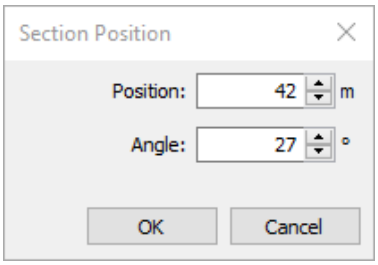
The small red triangle shows the kiln trigger position (as set in the Configuration). Blue arrow is the angle position marker. Dragging it you can see brick and coating parameters at any point along the kiln circumference.

Changing section position

To change section position, click on the kiln with the left mouse button and holding it drag the mouse left or right. Mouse wheel can be also used for this purpose.

You can change the section position by dragging the cursor at the kiln design view or at the 2D infrared image view (if it is displayed).

You can also set the exact section position and value of the angle marker manually. Click **Set Section Position** in the context menu (or press the appropriate button in the local toolbar) and key in needed position and angle value.



Colored bricks

Section 3D has one more display mode: Colored Bricks. In this mode color of bricks is defined by mixing the original texture color with the color of corresponding brick zone taken from the refractory structure.

Click the corresponding button in the local toolbar (or choose menu **3D / Brick Zones with Colors**) to see refractory zones in different colors.

Scene arrangement

1. The local toolbar contains a slider that rotates scene from 60° to 120°.
2. Section position can be changed by mouse wheel or mouse moving while left button pressed.
3. Angle position marker (blue arrow) can be dragged when the mouse pointer is over it (the mouse pointer changes its shape).
4. Double-click on the section position marker to open the Section Position dialog.
5. Double-click on any area outside the blue arrow to reset the scene to the normal position and orientation.

Kiln end-view 3D

Kiln end-view is a special case of the Kiln Section 3D view when scene angle is fixed at 90°. The rest of the functionality is the same.

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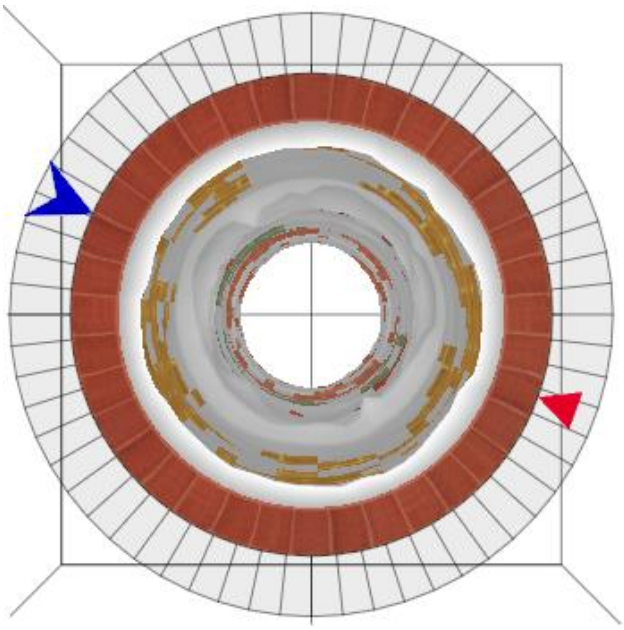
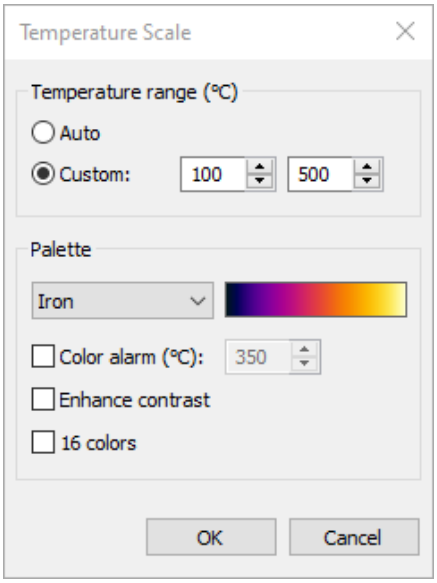


3.10. Temperature scale and palette

In infrared images color of every pixel depends on its temperature. CS400 has means to adjust this dependency to make visual appearance of the kiln shell image better and to intensify important details. To set relation between colors and temperature you need to define *temperature range* and select *color palette*.

To configure temperature scale use main menu **Configuration / Temperature Scale**:



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Temperature range

Temperature range defines visible temperatures of the image. Pixels with temperatures below the lower range limit are shown with the darkest palette color (color at the bottom of palette); pixels with temperatures above the upper range limit are shown with the brightest palette color (color at the top); pixels with temperatures in between have corresponding intermediate palette colors.

There are two possibilities that you can use to set temperature range:

1. **Auto:** CS400 calculates the best range automatically taking into account the current image histogram.
2. **Custom:** you can set your own range limits. This is useful when you are not interested in all temperatures present on the image but need a sub-range.

Palette

Palette is the set of colors that allows to see temperature differences. CS400 has a wide selection of color palettes that can be used to display infrared images. Sometimes one palette suits better to reveal the problem than the other.

Color alarm: pixels with temperatures above the selected value will be displayed with a contrast color. This contrast color depends on the used palette and cannot be user selected.

Enhance contrast: automatically distributes colors on the palette to improve image contrast.

16 colors: leaves only 16 colors on the palette.

3.11. Reference views

The Monitoring window is divided into two parts.

The upper part of the window is the Kiln view. It represents the actual image of the kiln shell in a 2D or 3D view.

The lower part is the **Reference view**. Reference view can display the following information:

- horizontal profile with the actual kiln shell envelope profile and alarm zones;
- temperature trends for analysis objects;
- image trend by images from the history;
- single history image as a temperature map or as an envelope profile;
- worst case image (since the indicated moment in the history) as a temperature map or as an envelope profile.

Reference view options are accessible through the **Reference** main menu or the **Reference** button menu that is in the right-hand corner of the reference window.

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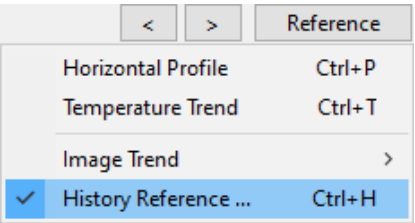


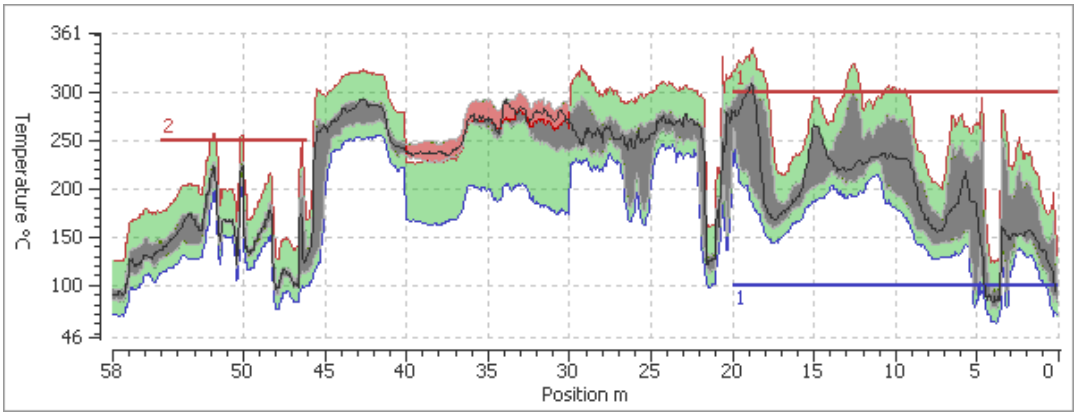
To learn more about the Reference view functionality, see these topics:

- Horizontal profile
- Temperature trend
- Image trend
- History reference

3.12. Horizontal profile

Horizontal profile can be viewed in the lower part of the Monitoring window, it is one of the several possible choices for the Reference view.

The X-axis shows position along the kiln, the Y-axis shows the temperature.



Horizontal profile consists of the following graphs:

- **Green** is the reference envelope profile (it is taken from the alarms configuration – see Envelope profile alarms for details).
- **Gray** and **red** is the envelope profile of the actual kiln shell image. When the envelope profile goes out of the reference envelope profile, it is drawn in the red color.
- **Black** moving line is the live profile coming from the scanners.
- Thin **red** and **blue** selvedge lines mark the high and low limits of the reference envelope profile.
- **Red** and **blue** horizontal lines (with numbers) are the alarm zones markers.

To get quick access to the profile and alarms configuration, use main menu **Configuration / Alarms** or press the corresponding button in the toolbar.

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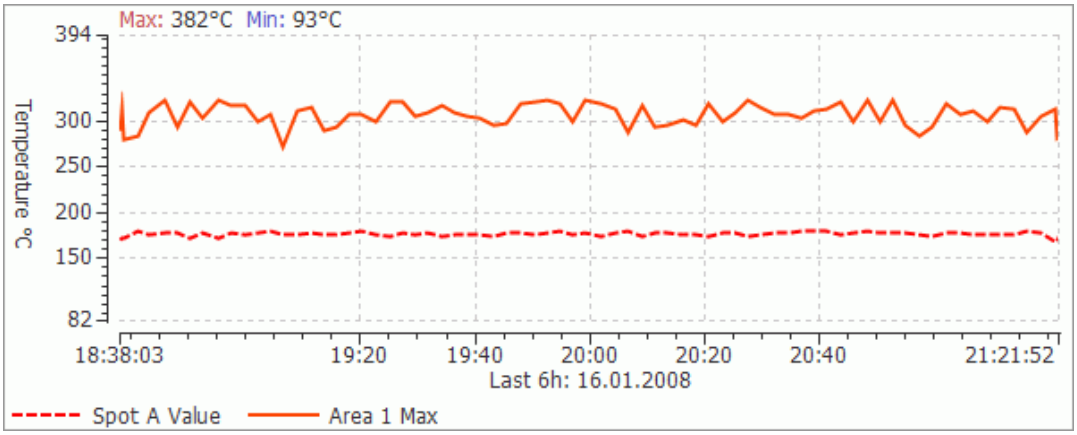
3.13. Temperature trend

CS400 can continuously monitor selected areas of the kiln shell and display trend graphs for them.

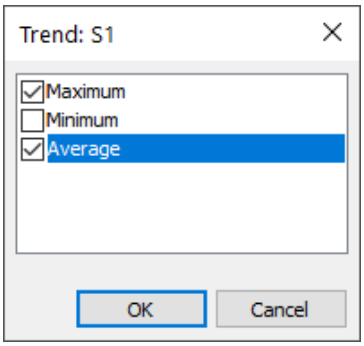
To start trend monitoring, follow the steps:

1. Switch to the Temperature map 2D view.
2. Place analysis objects to the areas which you want to monitor in the trend. All analysis objects can be monitored: spots, lines, areas, slices and intervals. See Analysis objects to learn more about analysis objects).
3. In the main menu select **Trend / Monitor All Objects**.

All analysis objects will be added to the trend and CS400 will start gathering data for these objects. After each kiln rotation new data will be added to the trend. At the same time, CS400 will start to load images from the kiln history and will update trend with historical values.



By default, only the maximum temperature of every object is monitored. But it is also possible to monitor minimum and average temperatures. To set this, click with the right mouse button on the analysis object and select **Monitor in Trend** command. In the small dialog, set the parameters you want to monitor in addition.



Monitor in Trend command can also be used when you do not want to monitor all the objects and want to select yourself which objects to monitor.

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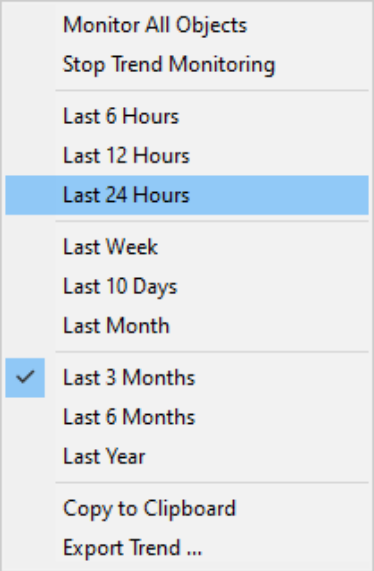
Note

When an analysis object is monitored in the trend, it is not possible to move it or to change its size and parameters.

Trend period

You can select displayed trend period. You may choose periods from *Last 6 hours* to *Last Year*. Select the corresponding command in the main menu **Trend** or in the trend window context menu.



Exporting trend data

Trend data can be exported to a **CSV** file (possible to view in Microsoft Office Excel). To do this, select **Trend / Export Trend** in the main menu. Choose location to save data, type a name, and push **Save** button.

Trend in the kiln history view

You can display temperature trend in the history view. Trend period will be the same as the selected history period. It is also convenient to use the cursor on the trend to navigate through kiln history.

1. Open the History tab and load the history data for some period of time (see Kiln history).
2. Place analysis objects.
3. In the main menu select **Trend / Monitor All Objects**.

CS400 will automatically load all images from the selected history period and will update trend with data from them.

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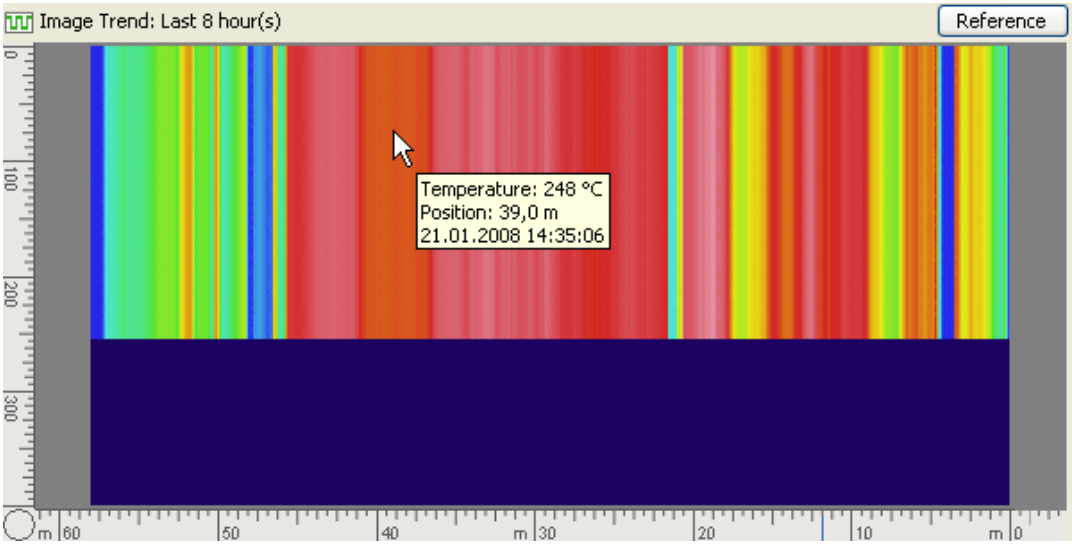
3.14. Image trend

Image trend is a thermal image composed from many kiln shell images taken from the history. Every horizontal line represents one image, it consists of maximum column temperatures along the X-axis. The X-axis corresponds to the kiln X-axis.

To show the Image trend, choose **Reference / Image Trend** and select a history type: *short-*, *middle-* or *long-term*. The operation of processing history data and building the image trend may take some time.



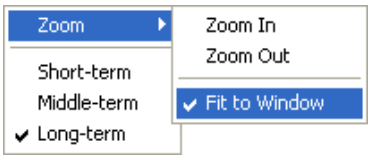
The number of lines in the trend image is equal to the number of kiln states that can be possibly saved in the history database (usually 400).

The most recent data is placed at the top. When new data is added to the history, Image trend is automatically updated – new data occupies the first (upper) line, and the rest descends one line down.

The Trend image caption shows what period of time is displayed (e.g. Last 17 hours, Last 6 months, etc.).

When you move the mouse cursor over the trend image, line and spot information is displayed in the small window.

The context menu allows to zoom in and out the image. You can also do it using the mouse wheel.



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Hint

Image trend is also available in History Tabs.

3.15. History reference

History reference is designed to compare the actual kiln state with an earlier kiln condition.

History reference can be:

- a single kiln shell image taken from the history;
- a worst case image since the indicated time in the history and to the current time.

History reference image is displayed using the same temperature scale and palette as the actual image, so the images can be easily compared.

History reference image can be also presented as an envelope profile and compared with the envelope profile of the actual image.

Note

History reference can use only the long-term history, it is only available if the long-term history is enabled (see History storage).

Worst case image

Worst case image is an infrared image which is composed from many infrared images taken from the kiln history. Every point shows the **maximum temperature** measured at this point since the indicated time.

Note

The worst case image is automatically updated when the new kiln state is saved to the long-term history storage, which is done by the defined schedule. So the worst case image is not always "worse" than the actual image. During periods between saving to the history, the actual image can be "worse".

History reference dialog

To load a History reference image, choose **History Reference** command in the **Reference** menu.

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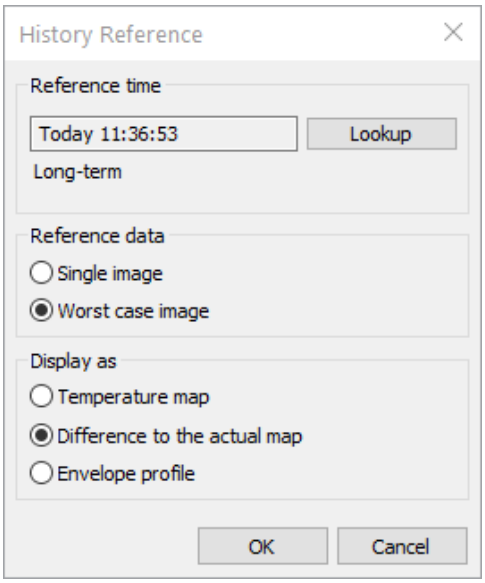


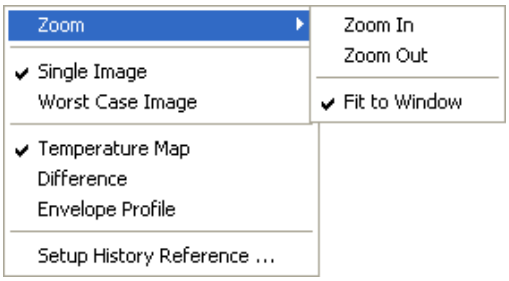
- In the dialog, press the **Lookup** button to display the list of all compatible records in the long-term history. Choose the needed date and time, and press **OK**.
- Choose **Reference data** – *Single image* or *Worst case image*. To build the worst case image all images saved in the history since the indicated time and until the current time will be checked.
- Then choose the way to display historical data – as *Temperature map*, *Envelope profile* or *Difference to the actual map*.
- When **OK** is pressed, corresponding data is shown in the Reference view.

History reference window

History Reference is the window with caption "History Reference - Single Image" or "History Reference - Worst Case".

If the **Envelope profile** option is selected, the reference window displays profile of the chosen history image in blue color and the actual image profile in gray and red colors (the actual profile is red when it goes out of the history profile bounds).

History reference window has the context menu with quick selection of what and how to display.



Zoom is available for the Temperature map only.

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Hint

History reference also works in History tabs.

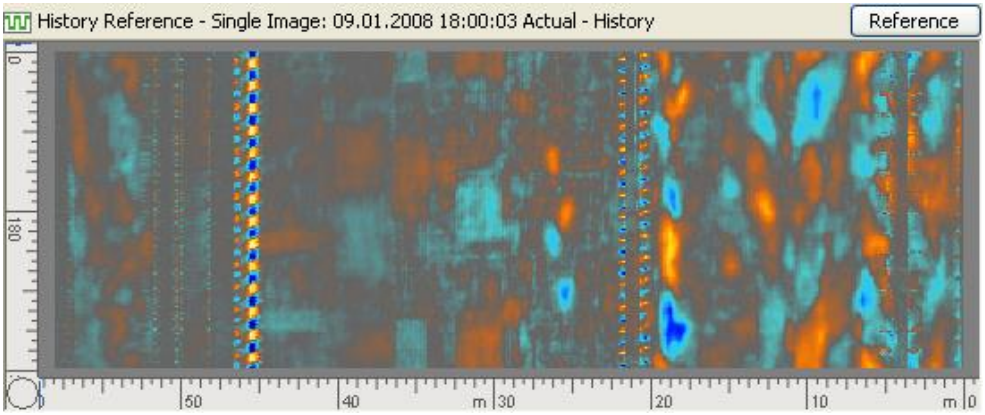
Difference display

History Reference image (single and the worst case) can be displayed as a **difference map**. In this mode the reference image is subtracted from the actual image.

The result is displayed using the special palette:

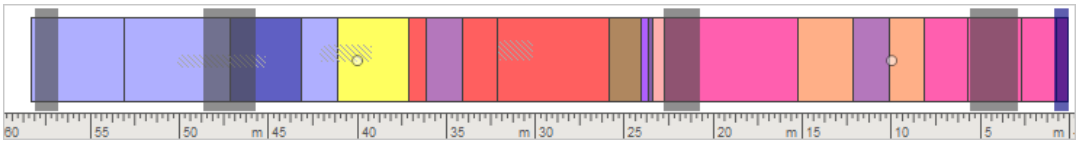
- places where the actual data has higher temperature than the history data are orange;
- places where the actual data is lower than the history data are blue;
- gray color means that the difference is not big.

To display difference map, choose **Difference to the actual map** in the History Reference dialog (Reference / History Reference command) or corresponding item in the Reference view context menu.



3.16. Refractory diagram

The kiln refractory structure is shown in the middle of the measurement screen or at the bottom. The refractory structure is taken from the configuration.



Refractory diagram displays:

1. Brick zones.
2. Special zones.
3. Drillings (drawn using circles).
4. Shell repairs (hatched areas).

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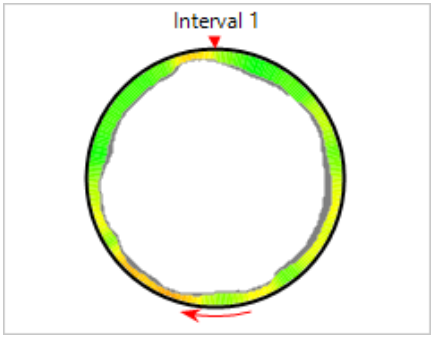
Double click on a refractory object to display its properties dialog (position, date of installation, initial brick thickness, etc.).

When bricks in one of the refractory zones reach the end of their typical life cycle (defined by 'date installed' and 'brick life' parameters), the **Refractory** alarm is generated and corresponding brick zones are marked with an exclamation mark.

When Kiln Section 3D or End-view is active, the section position is marked with a vertical marker. Dragging this marker moves the section position.

3.17. Thickness / Coating diagram

Thickness / Coating diagram is placed at the right bottom corner of the screen. It displays the worst case diagram with minimum brick thickness and maximum coating thickness along the selected kiln area. It also shows the kiln trigger position and the rotation direction.



Depending on the active kiln view the data in the diagram refers to:

- the whole kiln,
- selected area or
- slice / section position.

When the Temperature map 2D view is selected, thickness diagram displays brick and coating data for the whole kiln. But if there are interval or slice analysis objects on the image and one of them is selected at the moment, thickness diagram displays data for the selected interval or slice.

Overall kiln data is also presented for the Virtual kiln 3D view. When the Kiln section 3D or the Kiln end-view are active, the diagram refers to the section position.

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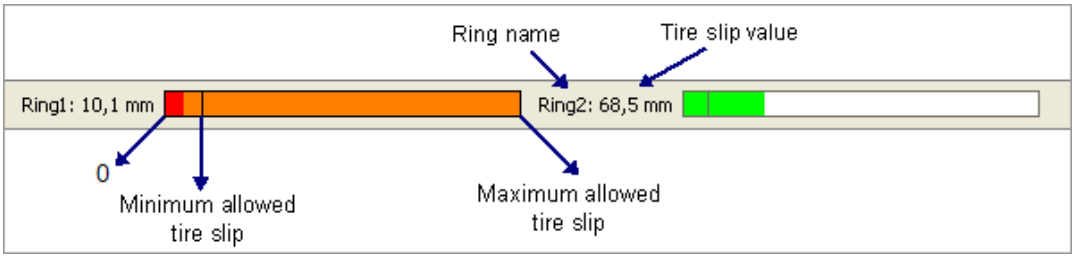
3.18. Tire slip indication

External rings are not fixed to the kiln and have a slightly bigger radius than the kiln. Besides, they are not rotated – kiln rotates the rings. Because of the change of temperature inside the kiln, the kiln diameter may become bigger and smaller (at some places). If kiln becomes bigger than the ring, the ring can damage the kiln. So, the ring should be all the time bigger than the kiln, and therefore its rotation time should always be bigger than the kiln rotation time, that is we should always have some *tire slip*.

When the kiln or a ring makes full rotation, system gets a signal from the kiln trigger sensor or a ring sensor, so that the kiln and the ring rotation time is known and can be compared. We calculate tire slips of all rings and generate alarms if the calculated value is out of the predefined range. Alarm is also generated if we have no signal during the period of maximum kiln rotation time.

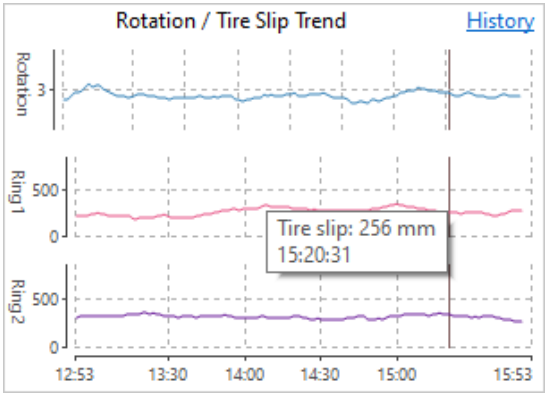
For more information see Tire slip monitoring topic.

Tire slip indicators are placed at the bottom of the measurement window. Each controlled ring has its own indicator. A tire slip indicator is a horizontal graphical stripe that changes its color depending on the ring condition. If tire slip falls into allowed range the bar is drawn in green, and the background is white. If tire slip value is outside the range, the bar becomes red, and the background orange.



Short tire slip trend

CS400 can display not only the current but also the recent rotation and tire slip values, several hours. To show them make sure that **View | Rotation / Tire Slip Trend** menu item is checked. Rotation and tire slip trends are displayed in the side view in the right part of the monitoring window:



If you click on the **History** link you will see tire slip trend in a separate window. Also you will be able to select large trend periods and load historical data. See Rotation / Tire slip history topic.

Trend period is 3 hours by default, can be configured in Linescano.ini:

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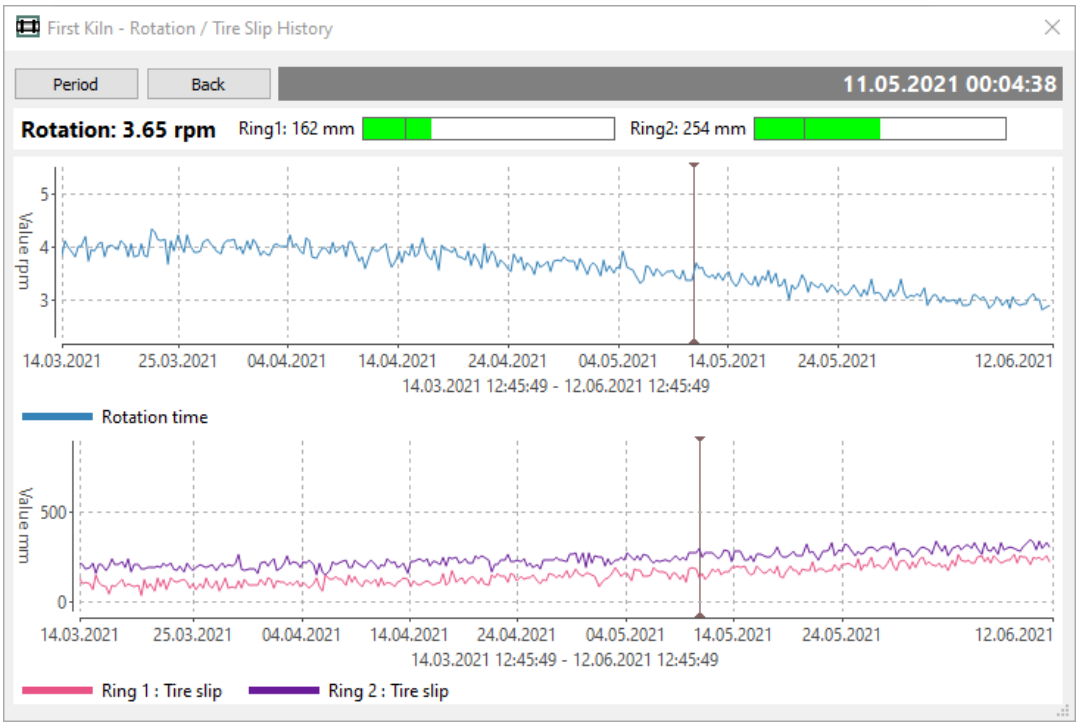
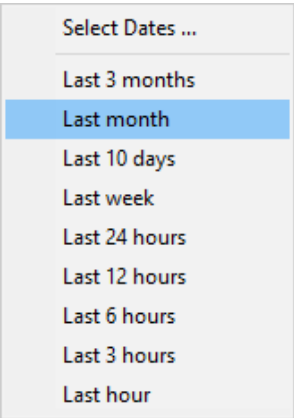
```
[ROTATION]
recent_trend_time_span = last_3_hour
```

3.19. Rotation / Tire slip history

To show Rotation / Tire slip history window use main menu **Monitoring | Rotation / Tire Slip History**.



To select displayed history period press **Period** button:



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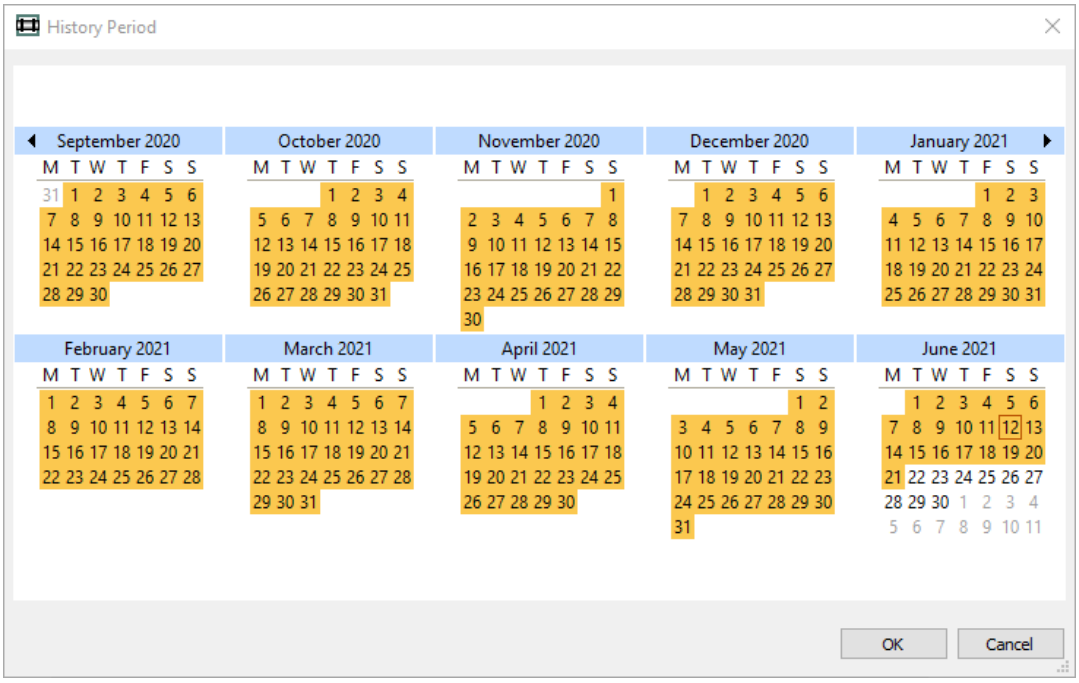
You can select one of the predefined "Last something" periods or set the dates you need by using **Select Dates** menu.



To select dates, click on the begin date and holding the mouse button move the mouse to the end date. Make dialog window bigger to be able to select larger periods.

> If you select a large period (more than a year) CS400 might not be able to load all the data. In this case the resulting period will be cut.

History cursor

Click on the diagram to show the cursor.

- Tire slip and rotation data that corresponds to the cursor position is displayed above the diagrams.
- You can move cursor using the mouse. Also with the mouse you can drag the trend to move the displayed period.
- Use the mouse wheel to change the time scale and see smaller or bigger periods.

3.20. Burning zone

To display the small burning zone view make sure that **View | Burning Zone** menu item is checked. Burning zone monitoring device must be configured, otherwise the menu item will not be available.

Information about burning zone is displayed in the side view in the right part of the monitoring window:

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Information includes:

- Measured temperature of the burning zone. If an IR camera is used, the maximum temperature on the image is used as the temperature of the burning zone.
- Instrument internal temperature. If the instrument internal temperature exceeds the limit defined in the configuration, Scanner alarm is generated.
- If the burning zone monitoring device provides video, video is also displayed in the burning zone view, but only if window is big enough and there is enough space for an image.

Note

Burning zone video is only available on CS400 server. Clients cannot display video.

Burning zone window

To see burning zone data in a bigger window and to display the burning zone temperature trend, click on the **More** link. Same window is shown if to select **Monitoring / Burning Zone Window** in the main menu.

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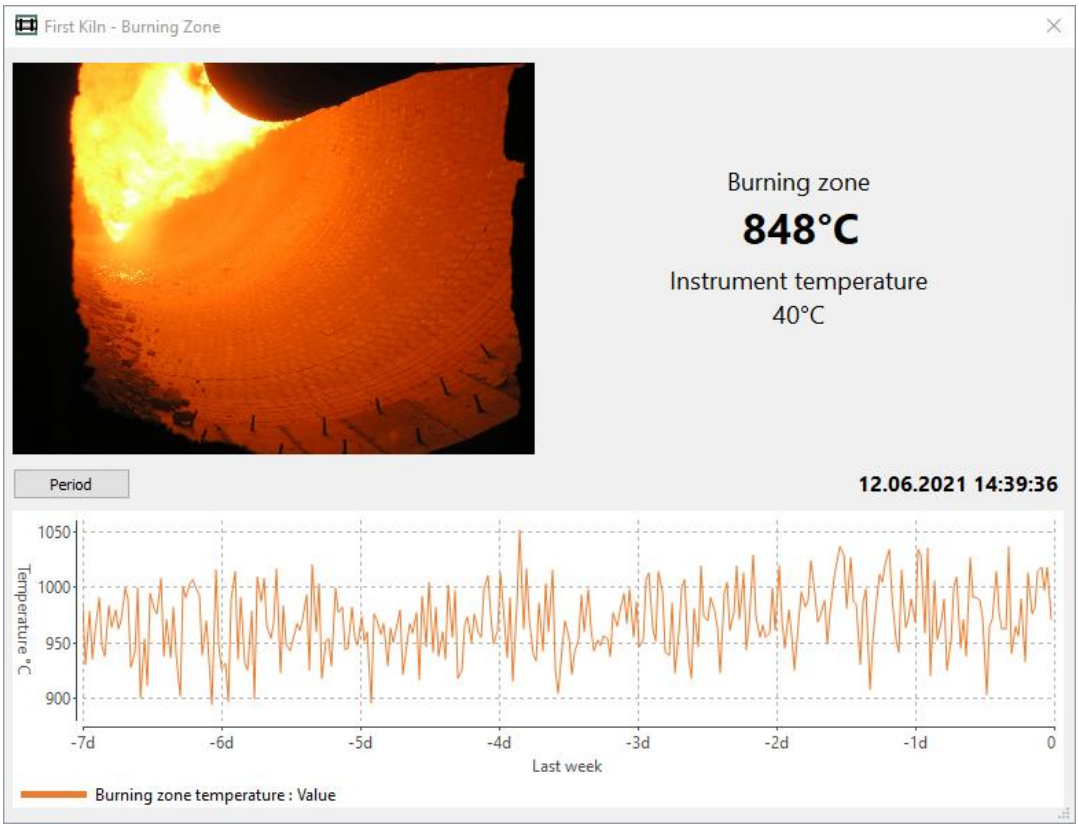
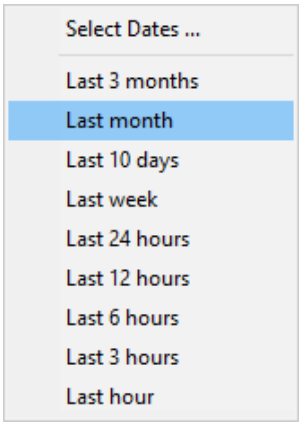


To select displayed history period press **Period** button:



Select Dates work same as in the tire slip history.

Burning zone history

Click on the diagram to show the cursor. Diagram caption will change its color to gray, this means that it shows history data, not the actual data.

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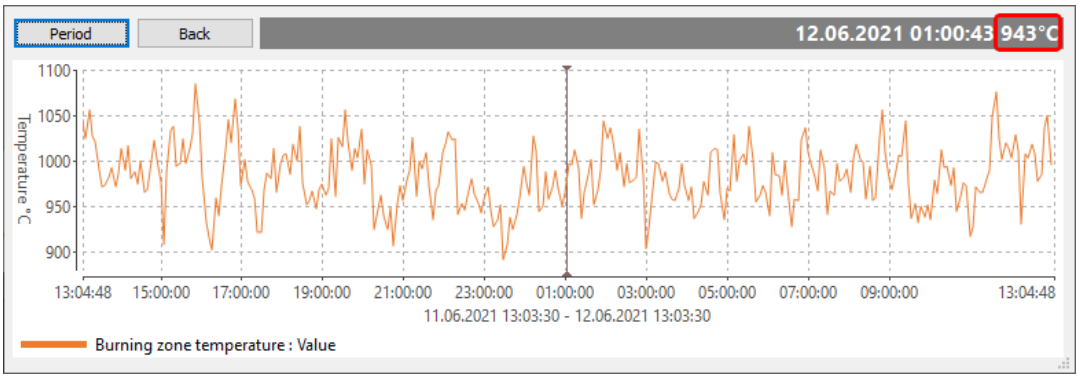
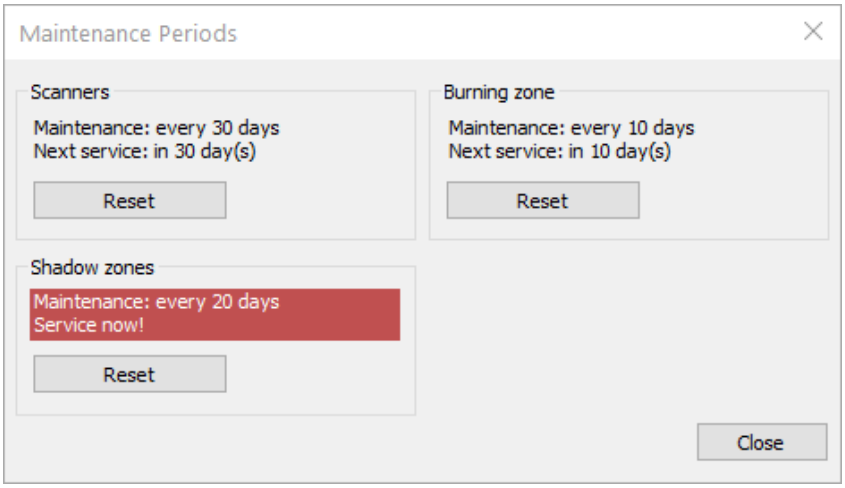


- Cursor position time and the corresponding burning zone temperature is show in the diagram caption with the gray background.
- You can move cursor using the mouse. Also with the mouse you can drag the trend to move the displayed period.
- Use the mouse wheel to change the time scale and see smaller or bigger periods.

3.21. Resetting maintenance alarm

Purpose of a maintenance alarm is to remind that it is time to inspect the monitoring instruments - check that everything is fine, clean the lenses and things like that. See Maintenance alarms configuration.

If you see that maintenance alarm is active in the alarms window, double click on the alarm line to open **Maintenance Periods** dialog. There is also **View / Maintenance Periods** item in the main menu



Click on the corresponding **Reset** button if the the necessary maintenance was done and the maintenance period can start from the beginning.

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3.22. Monitoring window layouts

Standard Layout

CS400 gives possibility to save the current windows layout as the standard in order to return back to it quickly at any time. The Standard Layout is also used when the application is restarted.

At any time you can switch back to the standard layout with just one click – on the corresponding button in the toolbar.

Saving current layout as the Standard Layout

To save current windows layout as the standard layout:

- adjust the measurement screen as you need it and
- in the main menu click **View / Save Current Layout as Standard**. This command is protected by Level 1 password (see Passwords).

The following parameters are remembered:

- Monitoring windows: number and positions.
- Kiln view mode: Temperature map 2D or one of the 3D modes.
- Kiln view, reference view and side view sizes.
- If it is a 3D mode: kiln view parameters - scene orientation, section position and so on.
- Reference view settings: what is displayed and the way it is displayed. But not the history reference time. The reference time is remembered individually for every opened tab.
- Thickness/ Coating, Refractory, Burning zone view, Rotation / Tire slip trend: visibility and sizes.

The standard layout is the same for all data sources, that is for remotely monitored kilns and for history tabs.

> **Note**
> Temperature scale parameters (range and palette) are not saved in the layout. To define default temperature scale parameters, use the Temperature scale configuration dialog.

3.23. Multiple monitoring windows

If you have several monitors attached to your computer it is convenient to have several monitoring windows. Especially it is convenient when you use CS400 to monitor more than one kiln. Several monitoring windows can also be used on a single monitor.

To add a measurement window, use main menu **Monitoring / New Window** or corresponding button in the toolbar.

Each measurement screen can show its own data and can be arranged independently. For example you can:

- Display different kilns in different monitoring windows.

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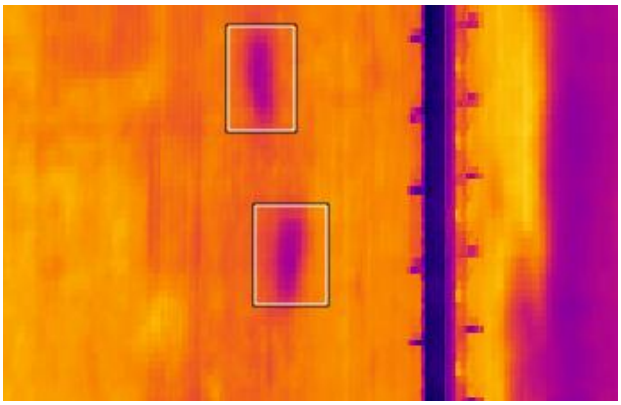
- Display monitored kiln data in one window and kiln history in another.
- Display 2D temperature map in one window and 3D virtual kiln in the other.
- Other similar uses.

You can remember number of opened monitoring windows by saving current layout as standard. After that, when application is restarted, all saved monitoring windows are reopened automatically.

3.24. Alarms suppression

If there are spots (hot or cold) on the kiln shell that should not participate in the alarm detection algorithm, they can be marked with **Suppress Alarm Tool** ( ):



Using this instrument, you can mark rectangular areas of the kiln shell that will not be scanned when envelope profile or zone alarms are checked.

In order to properly maintain alarm suppression history, it is not allowed to move a suppression area later than 1 hour after it was created. You can delete the old area and create a new one.

Alarm suppression summary log

CS400 maintains a text log file with summary of all alarm suppression areas.

Every record in this file has the following data:

1. Date and time when alarm suppression object was created (UTC).
2. Left and right coordinates of the area (in meters) – L, R.
3. Top and bottom coordinates of the area (in degrees) – T, B.

Example: 2019-03-18 11:34:12 L: 25.0051 R: 11.7415 T: 48.8571 B: 164.571

Rules used to create the log file:

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- When you create a new area, it is automatically added to the log file.
- If to move an area, its position is updated in the log file.
- When you delete an area, it is not deleted from the log file and can be used for reference when the kiln is stopped for repair.
- When all areas are deleted (for example by using menu Analysis | Delete All Objects), a new log file is started.

Folder with the log files can be open using main menu **View / Log Files**. The file is named **alarm_suppression.log**.

3.25. Brick and coating thickness calculation method

Brick and coating calculation is based on two equations, one for heat radiation, the other for heat conduction:

Heat radiation:

$$P = \varepsilon\sigma A(T_{hot}^4 - T_{cold}^4)$$

P is radiated power;

A is radiating area;

ε is emissivity;

σ is Stefan's constant = 5.6703*10^{-8} watt/(m^{2}K^4);

T_{hot} is temperature of the radiator;

T_{cold} is temperature of the surroundings.

Heat conduction:

$$\frac{Q}{t} = \frac{kA(T_{hot} - T_{cold})}{d}$$

Q is heat transferred in time t;

k is thermal conductivity;

A is area;

T is temperature;

d is thickness.

Formula to calculate temperature inside the kiln (at light-up), assuming there is no coating and brick thickness is known:

$$T_{in} = \frac{\varepsilon\sigma(T_{out}^4 - T_A^4)d_B}{k_B} + T_{out} \quad (1)$$

T_{in} is temperature inside the kiln at light-up;

T_{out} is kiln shell temperature;

T_A is ambient temperature;

d_B is initial brick thickness;

k_B is thermal conductivity of brick.

Assuming that the internal temperature is kept relatively constant for the whole production run any changes in the shell temperature can be attributed to brick wear and / or coating build up.

Formula for brick thickness calculation (with no coating):

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$$d'_B = \frac{k_B(T_{in} - T_{out})}{\varepsilon\sigma(T_{out}^4 - T_A^4)} \quad (2)$$

Coating thickness calculation, when brick thickness is known:

$$d_C = \left(\frac{T_{in} - T_{out}}{\varepsilon\sigma(T_{out}^4 - T_A^4)} - \frac{d'_B}{k_B}\right)k_C \quad (3)$$

Assumptions:

- Internal temperature estimation is run in the absence of coating.
- Internal temperature of the kiln stays relatively constant during the whole production run or operator keeps temperature values in the system always updated.
- Internal temperature is relatively constant along each refractory zone.
- Steel shell is ignored in the calculation.
- Kiln shell temperature growth is due to brick loss. While reduction in temperature is caused by coating build-up.

Algorithm for brick and coating thickness calculation

- Formula (2) is used to calculate the actual brick thickness for each point on the scanned kiln shell.
- If the new brick thickness is smaller than the brick thickness calculated before, the system decides that there is no coating and brick is being worn out.
- If the calculated brick thickness exceeds brick thickness know by previous revolutions, the system assumes that coating is building up.
- When the brick thickness is known we can use formula (3) to calculate the coating thickness.

To minimize random errors, the brick thickness map is not updated instantly. A weighted average between recently calculated values and remembered values is used:

$d = (1 - k)d + kd_{last}$

d is the updated value in the brick thickness map;

d_{last} is the newly calculated brick thickness value;

k is the averaging weight, value is taken from Linescano.ini:

```
[THICKNESS]
accumulation_coefficient = 0.1
```

Important

For the brick estimation method to work it is necessary to set the correct temperatures inside the kiln for each brick zone. See Temperature inside the kiln for details.

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3.26. Temperature inside the kiln

Protected by Level 1 password.

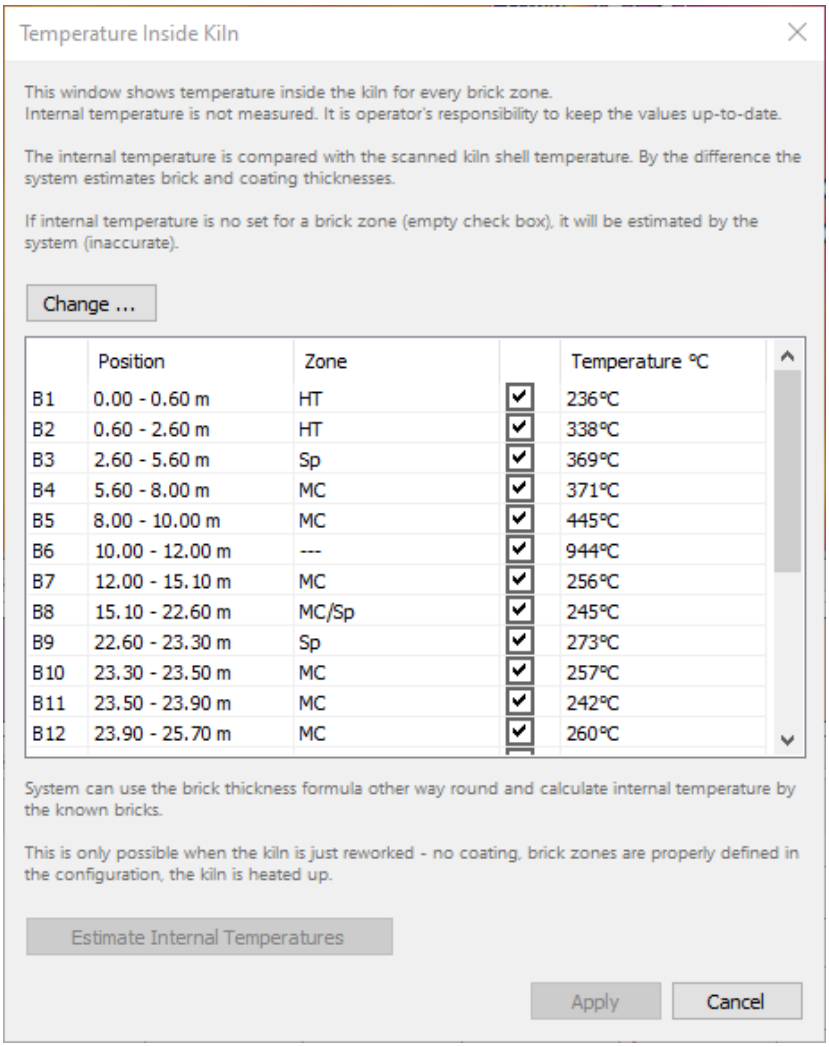
It is important to keep kiln internal temperatures up-to-date. These values are needed for brick and coating thickness estimation. Each brick refractory zone may have its own internal temperature value.

Inner temperature can be set manually by the operator, or estimated by the scanning system. The scanning system makes the following assumptions when it calculates the inner temperatures:

- There is no coating;
- Brick parameters (thickness and conductivity) are correctly set in the kiln configuration.

Temperature inside kiln dialog

Choose **Configuration / Temperature Inside Kiln** in the main menu. The dialog shows inner temperature value for every brick zone.



	Position	Zone		Temperature °C
B1	0.00 - 0.60 m	HT	☑	236°C
B2	0.60 - 2.60 m	HT	☑	338°C
B3	2.60 - 5.60 m	Sp	☑	369°C
B4	5.60 - 8.00 m	MC	☑	371°C
B5	8.00 - 10.00 m	MC	☑	445°C
B6	10.00 - 12.00 m	---	☑	944°C
B7	12.00 - 15.10 m	MC	☑	256°C
B8	15.10 - 22.60 m	MC/Sp	☑	245°C
B9	22.60 - 23.30 m	Sp	☑	273°C
B10	23.30 - 23.50 m	MC	☑	257°C
B11	23.50 - 23.90 m	MC	☑	242°C
B12	23.90 - 25.70 m	MC	☑	260°C

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To change the temperatures, press **Change** button. This action require Level 1 password.

Estimation by the system

The system needs the kiln shell temperature map to estimate the inner temperatures. Infrared image of the kiln shell must be already acquired and displayed in the monitoring window. Press **Estimate Inner Temperatures** button to calculate inner temperatures for every brick zone. New values will be saved in the system only when you press **Apply**.

Manual setup by the operator

You can set new or correct the estimated temperature values for every brick zone. Click on the temperature value in the table and enter a new value.

New values are saved in the system only when you press **Apply**.

3.27. Resetting brick thickness map

To estimate brick thickness CS400 also uses brick thickness values calculated at previous rotations. These values are automatically loaded from the history storage. Sometimes the historical values are wrong (for example because of a system breakdown). In such cases it is possible to tell the system to start brick thickness estimation procedure from the actual moment and not to use the older history data.

Use main menu **Configuration / Reset Thickness Map**.

This function should be used only if you suspect something went wrong with brick thickness calculation. CS400 automatically handles all "normal" situations when thickness map has to be restarted, e.g. after changes in kiln configuration or in the refractory.

3.28. Kiln history

History is available for kilns monitored locally on this PC and for kilns monitored remotely through the network (history storage on the server must be enabled and configured for remote access).

History storage settings can be viewed and changed in the configuration - see History storage.

History tab

Kiln history is displayed in a similar way as the actual kiln data is displayed - in the monitoring window.

To open history, in a monitoring window select **Monitoring / Kilns History** in the main menu or press the corresponding button in the toolbar. Then, in the **History Tabs** dialog, select a kiln (local or remote) to show history for, and press OK. A new tab will be added to the monitoring window. History tabs contain kiln name, caption "History" and the selected history period.

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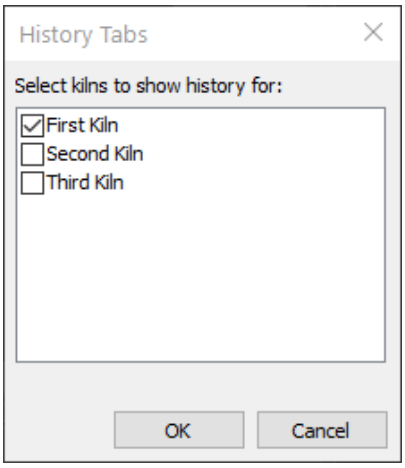
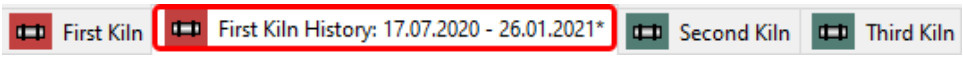




Using the same History Tabs dialog you can close history tabs. Another methods of closing history tabs is to click with the right mouse button on the tab and select **Close** in the menu.

Selecting history period

To quickly choose what period of recorded history to load click **History / History Period** in the main menu and then click the period that you want to load:

- *Last Hour* (short-term history);
- *Last 4, 6, 12 or 24 Hours* (short-term history);
- *Last 3, 5, 7 or 10 Days* (middle-term history);
- *Last 2 Weeks, 1, 3 or 6 Months* (long-term history);
- *Last Year* (long-term history).

Last "something" starts from the last saved record in the history, not from the current time. Though, normally if kiln monitoring is running the current time corresponds to the last saved record time.

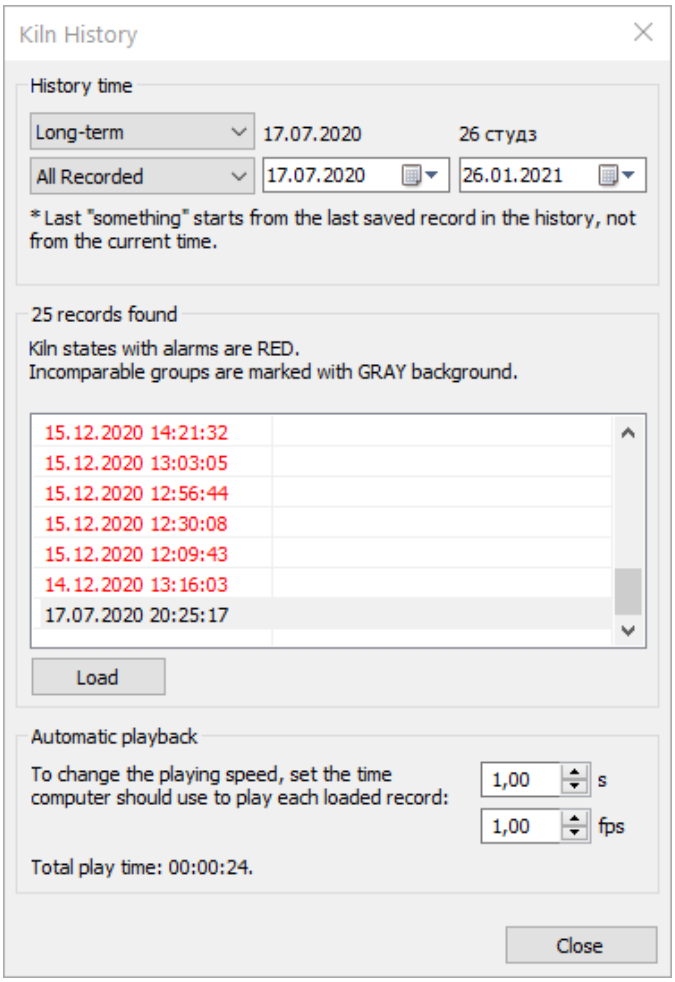
Some of the mentioned commands may be disabled if the corresponding history type is not enabled.

Kiln history dialog

History period

In addition to the quick period selection in the menu you have more control for the period selection in the **Kiln History** dialog. In this dialog you can also adjust the speed for a VCR kind of history playback.

To show the Kiln History dialog, choose **History / History Setup** in the menu or press the appropriate button in the toolbar.



In the first combo box, choose the history type you are interested in (*short*-, *middle*- or *long-term*).

In the second combo box, choose the period of interest or indicate a custom period in two time pickers on the right (available only for the long-term history).

In the "found records" field the program displays how many records were found by your request and gives the list of the found records. The first column in the list shows state date and time, the second column - state labels.

Load button loads the selected kiln state to the monitoring window. You can also double click on a state in the list to load it.

Kiln states with alarms are marked with the red color. Incompatible kiln state groups are marked with gray background color. Kiln states from different groups (incompatible states) cannot be compared because different configuration settings were used to record the data.

Playback speed

The playback speed can be adjusted in two ways:

- Time in seconds to display one record.

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- How many frames to display per one second (fps).

When you change one parameter, the other is recalculated automatically. The program then displays the time needed to play all loaded records.

Playing history states

When you open a history tab, the history toolbar is displayed.

It is possible to play all loaded records (kiln states) forward or backward. The playback time depends on the number of records and time set to play each of them in the Kiln History dialog.

To pause the playback, use the Pause button in the middle. This button is enabled only during playback.

The slider displays the current position among all records. To the right of the slider the currently displayed kiln state date and time is shown.

Using the **Delete** button you can erase a record from the history. In this case it will be physically deleted from the history database. This action is protected by Level 1 password (see Passwords) and cannot be executed for kilns accessed remotely through the network.

Automatic history playback is only available in 2D views. During automatic history playback it is not possible to activate any of the 3D views. However, even in 3D, you can switch between frames manually.

The **History** menu duplicated the toolbar and contains several additional commands:

- First State – moves to the first loaded record (to the beginning);
- Last State – moves to the last loaded record (to the end).

Other features that are available when history data source is active are similar to those in the normal monitoring mode. You can perform thermal analysis of the 2D image, make kiln sections, measure brick and coating thickness, build trends and so on. Your actions in a History tab will not influence other tabs. For example, if you add or deleted analysis objects in a history tab, analysis objects in other kiln tabs will stay unchanged

Kiln state labels

There is a possibility to save the actual kiln state to the history storage out of the defined schedule. This is usually done to remember a kiln state which show something unusual. When such a kiln state is saved, operator can specify a text label describing the case. These labels are shown in the frames list in the second column.

Use main menu **Extras / Label Kiln State** to label kiln states, and **Extras / Save Kiln State to History** to save current kiln state to the history outside the history recording schedule. These commands are available for online tabs, not for the history tab.

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3.29. Access to measured data for thrid-party applications

OPC UA

OPC UA implementation in CS400 does not require any configuration. Also it does not use any authentication and allows anonymous access.

CS400 OPC UA address space contains the following objects.

Kiln1, Kiln2, ...: KilnType

Component	DataType and Unit	Description
KilnName	String	Kiln name specified in the configuration
Monitoring	Boolean	Kiln monitoring is running
Synchronized	Boolean	Signal from the kiln trigger is present and stable
SystemOk	Boolean	No hardware problems (same as system is running signal)
Alarm	Boolean	Kiln alarm state (true if there is at least one active alarm present)
TemperatureMin	Double, degree Celsius	Measured minimum temperature value on the kiln shell
TemperatureMax	Double, degree Celsius	Measured maximum temperature value on the kiln shell
Rotation	KilnRotationType	Kiln rotation information
TSM	KilnTSMType	Tire slip monitoring information
AlarmZones	KilnAlarmZonesType	Contains information about each alarm zone
Profile	KilnProfileType	Envelope profile of the kiln shell image
BurningZone	BurningZoneType	Burning zone information

Rotation: KilnRotationType

Part of a KilnType object.

Component	DataType and Unit	Description
LapCounter	UInt32	Kiln revolution counter since monitoring start

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Component	DataType and Unit	Description
LapTime	Double, second	Last kiln revolution duration
LapTimeVariation	Double, second	Kiln revolution time difference during 5 last laps
RotationSpeed	Double, revolutions per minute	Kiln rotation speed

TSM: KilnTSMType

Part of a KilnType object.

Component	DataType and Unit	Description
Ring1	TireSlipType	Tire slip data of Ring1
Ring2	TireSlipType	Tire slip data of Ring1
...		
RingN	TireSlipType	Tire slip data of RingN

Ring1, Rimg2, ...: TireSlipType

Part of a KilnTSMType object.

Component	DataType and Unit	Description
TireSlip	Double, millimeter	Estimated tire slip. EURange property contains permissible limits defined in the kiln configuration.
TireSlipStdDev	Double, millimeter	Tire slip value standard deviation calculated from several kiln revolutions. EURange property contains permissible limits defined in the kiln configuration.
Alarm	Boolean	Alarm set when the estimated tire slip value is out of permissible range or if measured tire slip values are not uniform.

AlarmZones: KilnAlarmZonesType

Part of a KilnType object.

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Component	DataType and Unit	Description
Zone1	AlarmZoneType	Alarm zone data for Zone1
Zone2	AlarmZoneType	Alarm zone data for Zone2
...		
ZoneN	AlarmZoneType	Alarm zone data for ZoneN

Zone1, Zone2, ...: AlarmZoneType

Part of a KilnAlarmZonesType object.

Component	DataType and Unit	Description
PosStart	Double, meter	Positing of the zone in kiln coordinates
PosEnd	Double, meter	Positing of the zone in kiln coordinates
LimitHigh	Double, degree Celsius	The upper temperature limit defined in the kiln configuration used to trigger the zone alarm
LimitLow	Double, degree Celsius	The lower temperature limit defined in the kiln configuration used to trigger the zone alarm
Hysteresis	Double, degree Celsius	Hysteresis to prevent alarm from turning off too quickly (defined in the kiln configuration)
TemperatureMin	Double, degree Celsius	The minimum temperature value in the zone
TemperatureMax	Double, degree Celsius	The maximum temperature value in the zone
TemperatureAverage	Double, degree Celsius	The average temperature value in the zone
Alarm	Boolean	Zone alarm state

Profile: KilnProfileType

Part of a KilnType object.

Component	DataType and Unit	Description
TemperatureMax	Double Array, degree Celsius	Array size is equal to the kiln shell IR image width. Each element contains the maximum temperature

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Component	DataType and Unit	Description
		value of the corresponding IR image column (maximum temperature along kiln circumference).
TemperatureMin	Double Array, degree Celsius	Each array element contains the minimum temperature value.
TemperatureAverage	Double Array, degree Celsius	Each array element contains the average temperature value.
PixToPosA	Double	Coefficient A to convert array index to kiln position:KilnPosX = A + B * index
PixToPosB	Double	See above
HighAlarm	Boolean	State of the envelope high alarm (kiln temperature at some point is higher than the defined envelope profile limit).
LowAlarm	Boolean	State of the envelope low alarm (kiln temperature at some point is lower than the defined envelope profile limit).

BurningZone: BurningZoneType

Part of a KilnType object.

Component	DataType and Unit	Description
Temperature	Double, degree Celcius	Measured temperature of the burning zone flame.
InstrumentTemperature	Double, degree Celcius	Measuring device internal temperature.
Alarm	Boolean	Set to true if the measured burning zone temperature is higher than the limit defined in the kiln configuration.
InstrumentAlarm	Boolean	Set to true if the measuring device internal temperature is higher than the limit defined in the kiln configuration.

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OPC Classic

If properly configured CS400 gives access to the measured kiln data and monitoring status through OPC DA 2.0 interface. Here is the list of OPC tags available for each monitored kiln:

OPC Tag	Value type and unit	Description
running	VT_BOOL	Kiln monitoring is running
synchronized	VT_BOOL	Signal from the kiln trigger is present and stable
system_ok	VT_BOOL	No hardware problems (same as system is running signal)
config_kiln_name	VT_BSTR	Kiln name specified in the configuration
config_observed_start	VT_R8, meters	X coordinate of the starting point of the kiln area observed by the scanners
config_observed_end	VT_R8, meters	X coordinate of the end point of the kiln area observed by scanners
kiln_shell_min	VT_R8, degrees Celsius	Measured minimum temperature value on the kiln shell
kiln_shell_max	VT_R8, degrees Celsius	Measured maximum temperature value on the kiln shell
brick_thickness_min	VT_R8, mm	Estimated minimum brick thickness (of all bricks in the kiln)
coating_thickness_max	VT_R8, mm	Estimated maximum coating thickness
zone_1_min .. zone_32_min	VT_R8, degrees Celsius	Measured minimum temperature in alarm zone 1 .. 32
zone_1_max .. zone_32_max	VT_R8, degrees Celsius	Measured maximum temperature in alarm zone 1 .. 32
zone_1_avr .. zone_32_avr	VT_R8, degrees Celsius	Measured average temperature in alarm zone 1 .. 32
rotation_time	VT_R8, seconds	Duration of the last full kiln revolution

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tire_slip_1 .. tire_slip_8	VT_R8, mm	Estimated tire slip in millimeters (tire 1 .. 8)
tire_delay_1 .. tire_delay_8	VT_R8, seconds	Revolution duration difference compared with the kiln revolution duration (tire 1 .. 8)
history_connection_string	VT_BSTR	Path to the history folder
last_short_term_record_time	VT_DATE	Time stamp (UTC) of the last short-term history record
last_middle_term_record_time	VT_DATE	Time stamp (UTC) of the last middle-term history record
last_long_term_record_time	VT_DATE	Time stamp (UTC) of the last long-term history record

Kiln state data saved on disk

After each kiln revolution CS400 saves current kiln state to files on disk. This function does not require configuration.

Kiln state data is saved in the kiln history folder.

```
<Kiln history folder>\State\last
    - state.json
    - image.csv
```

Path to the kiln history folder can be set in the kiln configuration.

state.json contains the followings data:

- *update_time_UTC*: time when data was updated (UTC);
- *image_width, image_height*: kiln image dimensions in pixels;
- *xA, xB, yC*: parameters to convert image pixel coordinates to kiln coordinates;
- *rotation*: measured kiln rotation data (*lap_counter*, *measured/nosignal/stable* states, *lap_time_s*, *lap_time_variation_s*);
- *rings*: measured tire slip for each ring (*measured/nosignal/uniform* states, *tire_slip_mm*, *tire_slip_stddev_mm*);
- *burning_zone*: measured buring zone temperature;
- *alarms*: list of alarms with their state (true or false).

image.csv contains kiln shell image temperatures:

- comma is used as columns separator;
- next line (0x0D, 0x0A) is used as lines separator;

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- number of columns correspond to *image_width* from state.json;
- number of lines correspond to *image_height* from state.json;
- temperature values are always in Celsius.

To convert image pixel position to kiln position, use the following formulas:

- Image coordinate system: left to right, top to bottom;
- Kiln coordinate system: defined in the kiln configuration (can be left to right or right to left, formulas work in both cases);
- "position along x kiln axis in meters" = *xA* + *xB* * x pixel pos";
- "position opposite to kiln rotation in degrees" = *yC* * "y pixel pos".

3.30. Logs

Every event and every alarm in CS400 is registered in logs files. There are the following logs:

1. Events log: events like monitoring started, monitoring stopped, kiln configuration changed, scanner communication problem, other hardware problem.
2. Alarms log: an alarm condition changed, alarm condition is reset by operator.
3. OPC server log: OPC events like a client connected or disconnected, OPC errors.

Each kiln has its own logs. Log data is separated by months.

To see the logs, use main menu item **View / Log Files**. This will open the folder with log files in Windows Explorer.

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CS400
User's Manual, Rev. 1.0.5, Oct 2021

128

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