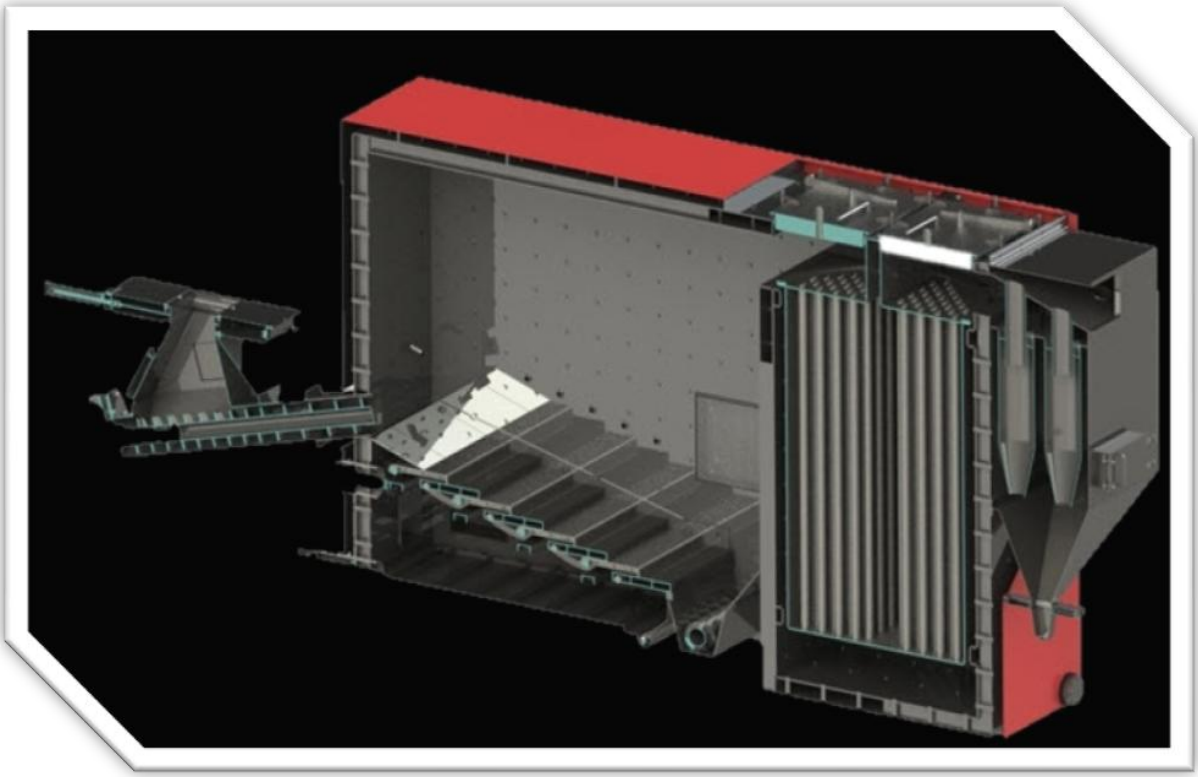
Instruction Manual Biomass boiler plant 1.5 MW



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CONTENTS

1. IMPORTANT NOTICE

Never handle the auger, blower; nor should you crawl in the hopper when the system is powered.
There will be no warning prior to the activation of these components.

The boiler must not be operated without properly securing the ash can and lid
The system is provided with an electrical current of 400/230V-50 Hz. An improper installation or improper repair can cause life-threatening electrical shock. Electrical connections must be performed by a person with the right skills and training. Performance of electrical installation must be carried out in COMPLIANCE with the relevant local rules.

Always disconnect the system from the electrical supply prior to starting maintenance work or servicing. The system must be connected to a separate electrical circuit, which is equipped with the proper circuit breaker and earth leakage breaker.

The boiler must be mounted to a functioning chimney with adequate draft. In the event that you smell smoke or see any other indication of improper draft of the chimney, all operation of your system must cease immediately and must remain so until a solution to the draft problem has been resolved. Continuing operation may result in death or injury.

Always read the manual before installing and / or repairing of the system. If in doubt, seek professional help.
As the control system is constantly being updated and new features / experiences are being added, it is the user's responsibility to keep the manuals and maintenance manuals updated.
Opentopcoversetc.withextremecaution.

When the boiler is in operation, there is a risk of high temperature below the top covers, which can causeburns.Avoid handling the boiler while it is in operation.
Never open the ash tray while the boiler is in operation
The system must be operated by skilled individuals.
Contact your dealer If you are in doubt as to the safe operational use of the boiler.

2. SAFETY RULES

This chapter is about security.
Do not attempt to install, use, maintain, or inspect the electrical cabinet unless you are completely careful. Read the installation guidelines and the attached documents in order to use the equipment properly. Do not use electrical equipment until you fully know the equipment, safety information, and instructions.In these installation guidelines, classified are safety levels for DANGER, WARNING,CAUTION.

DANGER

DANGERindicates an immediate risk of high risk, such as death or serious bodily injury (loss body parts or permanent disability). In the event of non-compliance with these signs, a direct consequence is caused - death or the most difficult bodily injury.

WARNING

WARNING means a possible risk of medium risk, such as death or (the most severe) bodily injury. At failure to comply with these signs is a likely consequence - death or the most serious bodily injury.

CAUTION

CAUTION indicates the risk of a lower risk, such as minor or medium-term injuries

IMPORTANT

IMPORTANT indicates the required holding or handling of the electrical cabinet. Failure to follow this manualleads to breakdowns in the electrical equipment or in its environment.

ADVICE

ADVICE is especially useful information and advice. These tips can help you make the most of itall the functions of the electrical cabinet.

2.1. Protection against electric shock

WARNING

• While the electrical cabinet is under voltage or while motors are working, do not open the door of the electrical cabinet or front cover of the wiring harness of the motor. Otherwise, you may suffer a stroke of electric current.
• Do not run motors if the terminal box cover is not mounted. Otherwise, you can touch connection terminals of the supply phase and suffer a shock of the electrical current. Even if motors are not under voltage (not power supplied), do not remove the front cover of the motor cables except for operation wiring or periodic inspection.
• Before starting the merger or inspection, check to make sure that the indicators (signal light bulb under voltage) on the cabinet door is off, wait at least 2 minutes after turning off and check that there is no residual voltage using a tester or similar device.
• This electrical cabinet and all motors must be earthed. Grounding must be done according to national and local safety requirements and electrical regulations. (NEC Chapter 250, IEC 536 Class 1 and other applicable standards)
• Any person involved in the merger or inspection of this equipment should be fully capable of works.
• Always install the frequency regulator before connecting it to the mains. Otherwise, you can sufferelectric shock or be injured.
• The use of the frequency control panel for parameter entry and control is allowed only with dryhands to prevent electric shock. Otherwise, you may suffer an electric shock.
• Do not expose cables to scratches, excessive stress, heavy loads, or compression. Otherwise, you may suffer a power failure.
• Do not replace the cooling fan of the electrical cabinet while the power is on. It's dangerous to changecooling fan while the power is on.
• Do not touch the controller cover with wet hands. You can suffer an electric shock.

2.2. Protection against fire

CAUTION

Electrical devices may also be potential sources of ignition. Ignition sources that can be generated fromforeign electrical devices are:
• electrical sparks and arcs;
• discharge of static electricity;
• overheating of equipment, warm surface;
• Sealed metal particles formed due to mechanical shock.
All electrical equipment must be installed in the enclosure with a minimum IP 54 protection rating.Particular attention should be paid to the performance of the connection clamp, the asynchronous motor connections, the luminaires,solenoid (el.magnetic) valves, transformers. The version must be executed with an extramechanical

protection to prevent the strain of the connectors. The supply lines must be fixed withmechanical protection.Temperature in the electrical cabinet should be limited bytemperature indicators orthermostats.

• If the frequency controller has failed, turn off the power via the main switch and switch offcommand voltage via automatic fuse.

• The closet in the surrounding area can heat the room considerably above 55 ° C, therefore,adequate protection againstaccidental contact and to maintain a safe distance from other devices and parts system.

2.3. Protection from injuries

CAUTION

• Only connect the voltage specified in the manual to each terminal. Otherwise, it may come to, equipment damage.

• Always make sure that the polarity is correct to prevent damage, etc. Otherwise, it may come to, equipment damage.

• While the power is on or for some time after power off, do not touch the breaking resistors because they are hot and you can burn yourself.

2.4.Wiring

CAUTION

• Do not install circuits or components (e.g. capacitors for power factor correction) on the output side frequency regulators, which are not approved by the manufacturer.

• The direction of rotation of the motor corresponds to the direction of rotation according to the controls (STF / STR) only if it is retained the order of the phase (U, V, W).

• The cable entry is on the underside of the cabinet in the corresponding cable entries

2.5. Terminal operation and adjustment

CAUTION

• Before starting, check and adjust the parameters. If you do not, it can get unexpectederrors in the management system.

• Check the direction of rotation of the engines. Unless you do so, unexpected system errors can occurmanagement.

• Check the correctness of the sensors, pressure transmitter, pt1000 probes, etc.

2.6. Operation

WARNING

• Be sure that the start signal is turned off before resetting the alarm on the frequency regulator. If you do not, the engine may suddenly run again.

• Only the three-phase asynchronous motor should be connected to the output terminals of frequency drive. Merging any otherelectrical equipment to the output of the frequency regulator may damage the equipment

CAUTION

• Do not use a magnetic coupler (motor protection switch) at the frequency converter input often start and stop. Otherwise, the life of the frequency regulator will shorten.

• The number of turns on and off for one hour for soft starter should not be greater than 6 per h. Otherwise, it would be it is necessary to install additional cooling devices.

• Always perform a scan before starting a frequency regulator that has been stored for a long-time probation period.

• To prevent damage due to static electricity, touch the nearest metal before touching electric components in order to remove static electricity from your body.

2.7. Emergency shutdown

CAUTION

•When the main switch on the primary side of the frequency converter is dropped and the power is turned off. Check out
possible wiring failure (short circuit), damage to the internal parts, etc. Determine the cause of "popping"then remove the cause and turn on the switch.

• When the protective function of the frequency regulator is activated, an alarm will occur which will be printed ondisplay. Take appropriate actions as described in the Frequency Regulator Manual,then reset it and continue working

2.8. Maintenance, inspection and replacement of parts

CAUTION

•Do not modify the equipment.

• Do not replace the parts not listed in this manual. If you do so, a malfunction may occuror damage to equipment.

• Periodically perform a visual inspection of the equipment. If necessary, tie the cable to prevent itconnectors get loosen.

• In case of failure or damage to the equipment. An expert must determine why there has been a malfunction or damage, andperform defective equipment. Then replace the damaged equipment with adequate equipmentcharacteristic.

3. CHARACTERISTICS OF ELECTRIC CABINET

Electrical cabinet described in tis section is designed, manufactured and programmed for use for Mobile,1.5 MW Biomass Boiler plant only, it can't be used for any other purposes, nor to be modified to a prior knowledge of manufacturer.

TECHNICAL INFORMATION

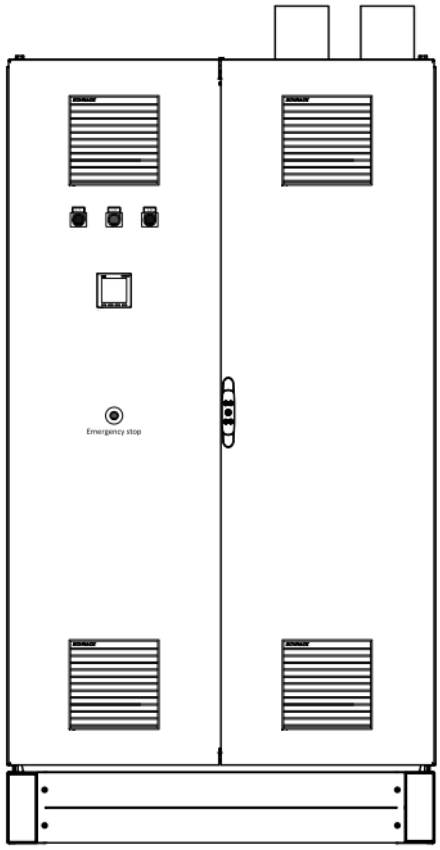
Model / Type:	+RO-BBC-1,5MW	Serial number:	001-37-2018
Rated voltage:	400V ± 10 %	Frequency:	50 Hz
Rated current:	max 160 A	Rated power:	max 75 kW
Dimensions HxWxD:	2200x2000x500 mm	Weight:	~ 475 kg
Colour:	RAL 7035	IP Protection class:	IP54
Temperature:	-10 °C do +50 °C	Humidity:	max 90 % RH
Cooling:	fan	Airflow:	116 - 578 m³/h
Noise in the work:	54 dB	Vibration:	max 5 m/s²
Production Year:	37 / 2018	Made in:	Serbia

Picture. No.1. Cabinet plate with basic info

Cabinets are designed manufactured and assembled in overall dimensions of (HxWxD) 2200mm X 2000mm x 500mm. There are two separate sections defined as Mains - Motor Control Section and Control section LVCP (Low Voltage Control Cabinet).

3.1. Mains – Motor Control section

Mains – Motor Control section is used to provide power supply, maintenance proper function of all driven motors, with it's protective functions and starting methods. In this section, main protection switch, motor protection switches, power supply components and frequency drive components are located.



Picture No.2. Front view of Mains – Motor Control Section cabinet

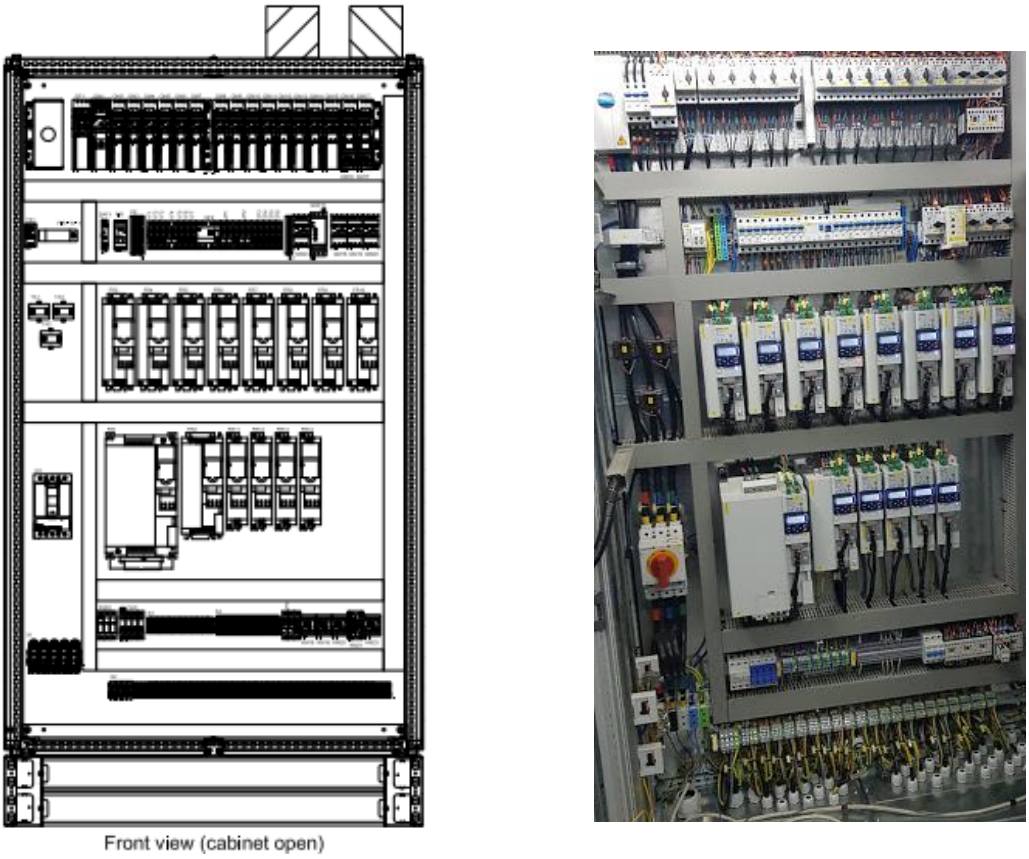
At front side of this section following elements are mounted

1. Cooling system (consists of 2 fans, and 2 ventilation grids)
2. 3 Indication lights (Yellow coloured for signalisation of each pf the phases)
3. Grid analyser – Provides basic electric parameters of the grid, power consumption, power factor etc.
4. Emergency push button – Trips the main protection switch and turns off power supply
5. Breaking resistors are located at top of the cabinet

WARNING

- Be assured that cabinet or breaking resistors are not covered and dust free – fire can be caused!
- Be assured that fan filters are regularly cleaned and dust free – in proper ventilation can cause damage of electronic equipment inside the cabinet

Picture No.3 Switches for manual start



Picture No.4. Front inside view of Main – Motor control section cabinet

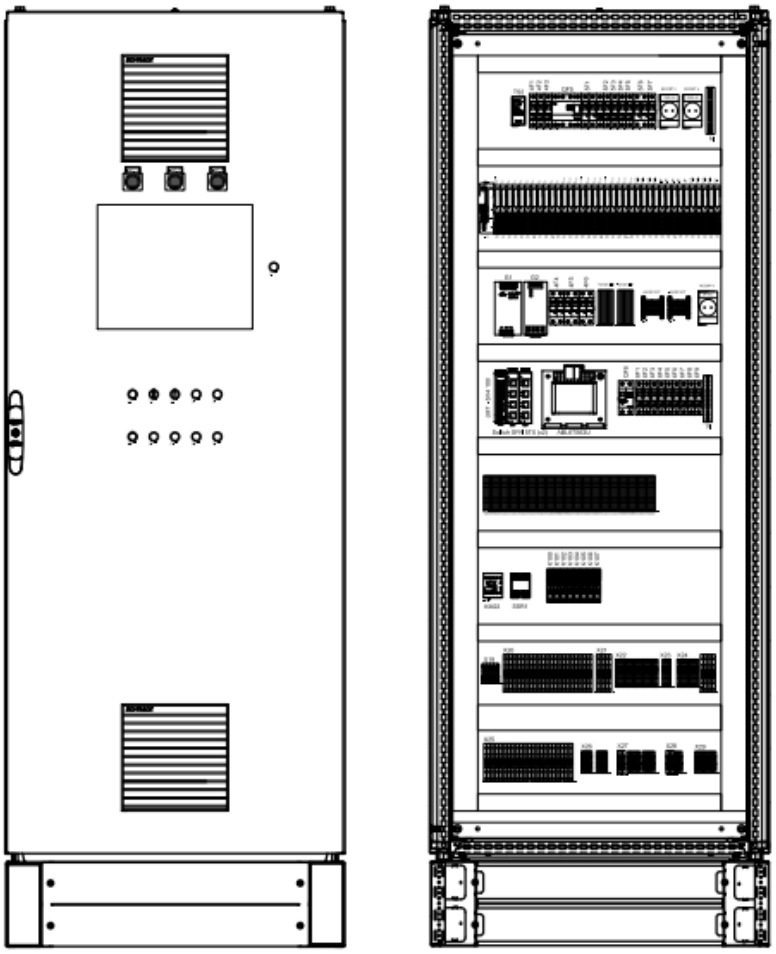
Inside the cabinet following equipment is installed, interconnected and adjusted:

1. Main circuit breakerIn=150 A
2. FIR – Earth leakage relay
3. Phase asymmetry relay
4. Current transformers for current measurement
5. Input and output terminal
6. Motor protection switches
7. Frequency drives
8. Soft starter
9. Fuses
10. Contactors
11. Overvoltage protection
12. Thermostat for actuating cabinet cooling fans

For more details about installed equipment, types and connections, please refer to ***Appendix 1. Wiring diagrams***

3.2. Low Voltage Control Cabinet – LVCP

This section of cabinets is used to collect data from sensors, frequency drives, to enable user input control and visualisation via HMI (human machine interface). It's integral part of electronic system which enables web visualisation and control via internet, data access over the mobile phone application. Main parts of this section are PLC configuration (which process all the data and runs the control algorithm), CMT-CVR – graphic device which enables the graphic for IPC and mobile phone app, IPC - Industrial Personal Computer, where visualisation is represented. This system is connected to a 2 LAN networks, where one of those goes over the Web and enables control over the internet via mobile phone or computer. System is equipped with redundant 24 VDC power supply, which is used in emergency power failure situation for supplying PLC, HMI and fire protection valve. This function will be described in software section. At front view there are emergency switches which provide one more way of enabling vital functions of the boiler plant, in case of lack of visualisation and web control.



Picture No. 5 Low Voltage Control Cabinet

At front side, following equipment is installed:

1. IPC – Industrial Personal Computer – for control and visualisation and service
2. Emergency switches and push buttons (for motor and hydraulics control)
3. Signal lights (Run, alarm and pre alarm state)
4. Fan and grids for ventilation

Inside the cabinet, main components are:

1. At top row, thermostat for cooling fans, fuses, power sockets
2. PLC configuration (CPU module + I/O modules + Communication)
3. Power supply, and redundant power supply module
4. Isolated transformer 230V AC / 230 V AC
5. 2 communication switches (Local area connection and Internet)
6. Relays
7. Solid state relays

8. Picture No.6. PLC configuration

Basic parts of PLC configuration inside cabinet are

1. CPU module – Lenze c300
2. I/O modules – various type (check wiring diagram for details, models and product data)

4.WIRING AND FIRST START

Use the cables of the appropriate types and sizes to connect the electrical cabinet to the electric motor and equipment in the field as defined in electrical diagram. Make sure that the power and power cords are properly dimensioned in order to ensure that the voltage drop will be max. 2%. If there is a distance between the electrical cabinet and the engine A large voltage drop in the mains power cable will cause a torque reduction especially when operating at low frequencies.

ADVICE

- The used cables must be shielded copper cables.
- Tighten the clamping screws with the specified tightening torques shown in the table.
- Poor tightening can result in short circuit or incorrect operation.
- Excessive tightening can cause damage to screws and devices, and may result in a short circuit and irregular work.
- Use rounded couplings. Crimping with the crimping tool recommended by the manufacturer of the feet.
- Use a larger diameter cable when the wiring distance is too high or when it is desirable to decrease the fall voltage (torque reduction) in the low speed range.
- The list of cables intended for connection is given wiring diagram

Wiring main power supply

DANGER

Un proper wiring can cause equipment damage, injury or death

1. Only qualified personnel may do the wiring
2. Use wiring diagram
3. Assure that main power cable is not under any voltage
4. Main power cable must go trough cable gland inside the cabinet
5. Disconnect main circuit breaker inside the cabinet – Q-1
6. Disconnect all automatic fuses inside Mains and LVC cabinet
7. Wire up ground terminal – PE
8. Wire up N conductor
9. Wire up phase conductor
10. Turn on power and check voltage, phase balance and N and PE conductor
11. When assured that all conductors are properly wired and voltage is correct, turn on main switch inside cabinet Q-1
12. Power up fuses one by one

Field devices and sensors

All parameters of biomass boiler plant are measured and controlled thanks to various types of signals from field and controllable parameters. All sensors are pre-wired, checked and calibrated before first start. Field signals are divided into two types, input and

Input signalshave purpose to provide measured value or status of controlled device, to PLC, which will according to a preprogramed algorithm define and conduct measures at output side of PLC. Here is the list of input signals, from field devices.

POS.	MARK	MEASURED VALUE	RANGE	SIGNAL TYPE
1	**TC-01**	Exhaust temperature	-50 - 300 C	pt1000
2	**TC-02**	Water temp - supply	-50 - 250 C	pt1000
3	**TC-03**	Water temperature, before boiler pump	-50 - 250 C	pt1000
4	**TC-04**	Water temperature, after boiler pump	-50 - 250 C	pt1000
5	**TC-05**	Water temp - burner inlet	-50 - 250 C	pt1000
6	**TC-06**	Water temp - burner outlet	-50 - 250 C	pt1000
7	**TC-07**	Ash conveyer temperature	-50 - 250 C	pt1001
8	**TC-08**	Fire temperature 1	0-1300 C	k type
9	**TC-09**	Fire temperature 2	0-1300 C	k type
10	**TC-10**	Dozing conveyer temperature	-50 - 250 C	pt1000
11	**PC-02**	Boiler Water pressure	0 - 2 bar	4 - 20 mA
12	**L-01**	Fliss level - 1 dozing bunker	300mm - 1350mm	4 - 20 mA
13	**L-02**	Fliss level - 2 dozing bunker	300mm - 1350mm	4 - 20 mA
14	**DP-01**	Vacuum pressure in burner	0 - 500 pa	4 - 20 mA
15	**DP-02**	DP at primary fan	0-5000 Pa	4 - 20 mA
16	**DP-03**	DP at multicyclone	0-5000 Pa	4 - 20 mA
17	**O-01**	Oxygen probe after burner	0 - 21 %	4 - 20 mA
18	**O-02**	Oxygen probe at exhaust air	0 - 21 %	4 20 mA
19	**G-01**	Hydraulic cylinder position - left in storage	3000 ohms	0-1000 ohm
20	**G-02**	Hydraulic cylinder position - right in storage	3000 ohms	0-1000 ohm
21	**G-03**	Hydraulic cylinder position - rost 1	3000 ohms	0-1000 ohm
22	**G-04**	Hydraulic cylinder position - rost 2	3000 ohms	0-1000 ohm
23	**G-05**	Hydraulic cylinder position - ash	3000 ohms	0-1000 ohm
24	**PC-03**	Oil pressure hydraulics 1	0- 250 bar	4 - 20 mA
25	**TC-11**	Oil temperature hydraulics 1	-50 - 250	PT-1000
26	**L-02**	Oil level switch hydraulics 1	on / off	contact
27	**PC-04**	Oil pressure hydraulics 2	0- 250 bar	4 - 20 mA
28	**TS-12**	Oil temperature hydraulics 2	-50 - 250	PT-1000
29	**L-03**	Oil level switch hydraulics 2	on / off	contact
30	**Q-01**	Air flow quantity - exhaust air	0-15m/s	4-20mA
31	**Q-02**	Air flow quantity - primary fan	0-15m/s	4 - 20 mA
32	**Q-03**	Air flow quantity - secondary fan	0-15m/s	4 - 20 mA
33	**Q-04**	Water flow before heat exchanger		4 - 20 mA

Table No. 1 List of field input signals

Output signals

Output signals from PLC, can be divided into two categories. Electromagnetic valves, both for hydraulic and pneumatic system, and motors (where each of the motors is drive with frequency drive, soft started or direct start).

Electromagnetic valves

NUM	COLUMN1	DESCRIPTION	VOLTAGE	MARK
1	EV101	Air shot - 1	230V	EV-AV 1
2	EV102	Air shot - 2	230V	EV-AV 2

3	EV103	Air shot - 3	230V	EV-AV 3
4	EV104	Airshot - 4	230V	EV-AV 4
5	EV105	Airshot - 5	230V	EV-AV 5
6	EV106	Airshot - 6	230V	EV-AV 6
7	EV201	Main Valve hydraulic aggregate H1	230V	EV-H1-COM
8	EV202	H1 left cylinder - FWD	230V	EV-GS1.1
9	EV203	H1 left cylinder - REW	230V	EV-GS1.2
10	EV204	H1 right cylinder - FWD	230V	EV-GS2.1
11	EV205	H1 right cylinder - REW	230V	EV-GS2.2
12	EV301	Main Valve hydraulic aggregate H2	230V	EV-H2-COM
13	EV302	H2 cylinder 3 - FWD	230V	EV-GS3.1
14	EV303	H2 cylinder 3 - REW	230V	EV-GS3.2
15	EV304	H2 cylinder 4 - FWD	230V	EV-GS4.1
16	EV305	H2 cylinder 4 - REW	230V	EV-GS4.2
17	EV306	H2 cylinder 5 - FWD	230V	EV-GS5.1
18	EV307	H2 cylinder 5 - REW	230V	EV-GS5.2
19	EV308	H2 cylinder 6 - FWD	230V	EV-EV-T1.1
20	EV309	H2 cylinder 6 - REW	230V	EV-EV-T1.2
21	EV310	H2 cylinder 7 ROOF - UP	230V	EV-EV-T2.1
22	EV311	H2 cylinder 7 ROOF - DOWN	230V	EV-EV-T2.2
23	EV401	EV slider - dozing - FWD	230V	
24	EV402	EV slider - dozing - REW	230V	
25	EV501	EV slider - Ash - FWD	230V	
26	EV502	EV slider - Ash - REW	230V	
27	EV601	EV tank water refill	230V	
28	EV601	EV fire protection	24 V	

Table No.2. List of EV – output signals

Motor list

All motor starters are located inside the cabinet, each motor has built in thermal and overcurrent protection, and some of the motors have built in PTC resistors, as protection from overheat. Motors driven with frequency drive have built in protections of frequency drive itself. Motor connection diagram, motor data, cable types and restriction are described in Appendix 1. Wiring Diagram.

NUM	MARK	NAME / DESCRIPTION	POWER (KW)	STARTING METHOD
1	M101	Main transporter from storage	4	Frequency drive
2	M102	Transporter Storage - Dozing	4	Frequency drive
3	M103	Dozing transporter	4	Frequency drive
4	M104	Slug transporter	4	Frequency drive
5	M105	Transporter - collector	4	Frequency drive
6	M106	Ash transporter from burner	1.1	Frequency drive
7	M107	Ash transporter	1.1	Frequency drive
8	M108	Multicyclone transporter	1.1	Frequency drive
9	M109	Rotational dozing of ash from multicyclone	1.1	Frequency drive
10	M110	Hydraulic aggregate storage	11	Frequency drive
11	M111	Hydraulic aggregate rost	1.1	Soft Start
12	M112	Exhaust fan	18,5	Frequency drive
13	M113	Primary fan	5,5	Frequency drive

14	M114	Secondary fan	5,5	Frequency drive
15	M115	Boiler pump	3	Direct start
16	M116	Cooling pump	3	Direct start
17	M117	Cyclone vibro motor	0.3	Direct start
18	M118	Main pump before heat exchanger	5.5	Frequency drive
19	M119	Ventilation fan - left	0.18	Direct start
20	M120	Ventilation fan - right	0.18	Direct start
21	M121	Startup burner	6	Direct start
22	M122	Pump for system refill	0.36	Direct start

Table No.3. Motor list

ADVICE

- For motor connection diagrams, cable type and all technical details please refer to Appendix 1. Wiring diagram
- For process and Instrumentation diagram please refer to Appendix 2. PID diagram

Startup, control and maintenance – Software

Biomass boiler plant is completely automated, and whole process is controlled by PLC as main CPU unit. It collects all signals, analog values and commands in various ways, some of them as analog values, some as digital, but most of data from motors are collected by Ethercat protocol of communication. Commands and setpoints are represented at CMT VIEWER application installed on IPC at the door of the cabinet. PLC has two protocols of communication, local area connection it it's IP address 192.168.5.99, and Ethercat communication protocol, as master station for communication with frequency drives and couplers. CMT SVR device, has a purpose of generating graphics, and it has also two LAN ports, where each of them is used for it's own LAN connection. One port as on PLC-LAN network, with it's IP address 192.168.5.20 and over this connection, communication is done with PLC. Other port has automatic domain settings, and it's used for INTERNET connection, through which web access is enabled. IPC as a device, is used as personal computer, where CMT Viewer application is located (for monitoring parameters of boiler plant), backup of software is located at this device to, and trough it remote access is possible via VNC or remote desktop. Main purpose of IPC is to have user friendly environment for operator to set up boiler plant, monitor, control and diagnose problems at boiler plant. It's equipped with touch screen, onboard keyboard, and redundant power supply in case of emergency power cut off.

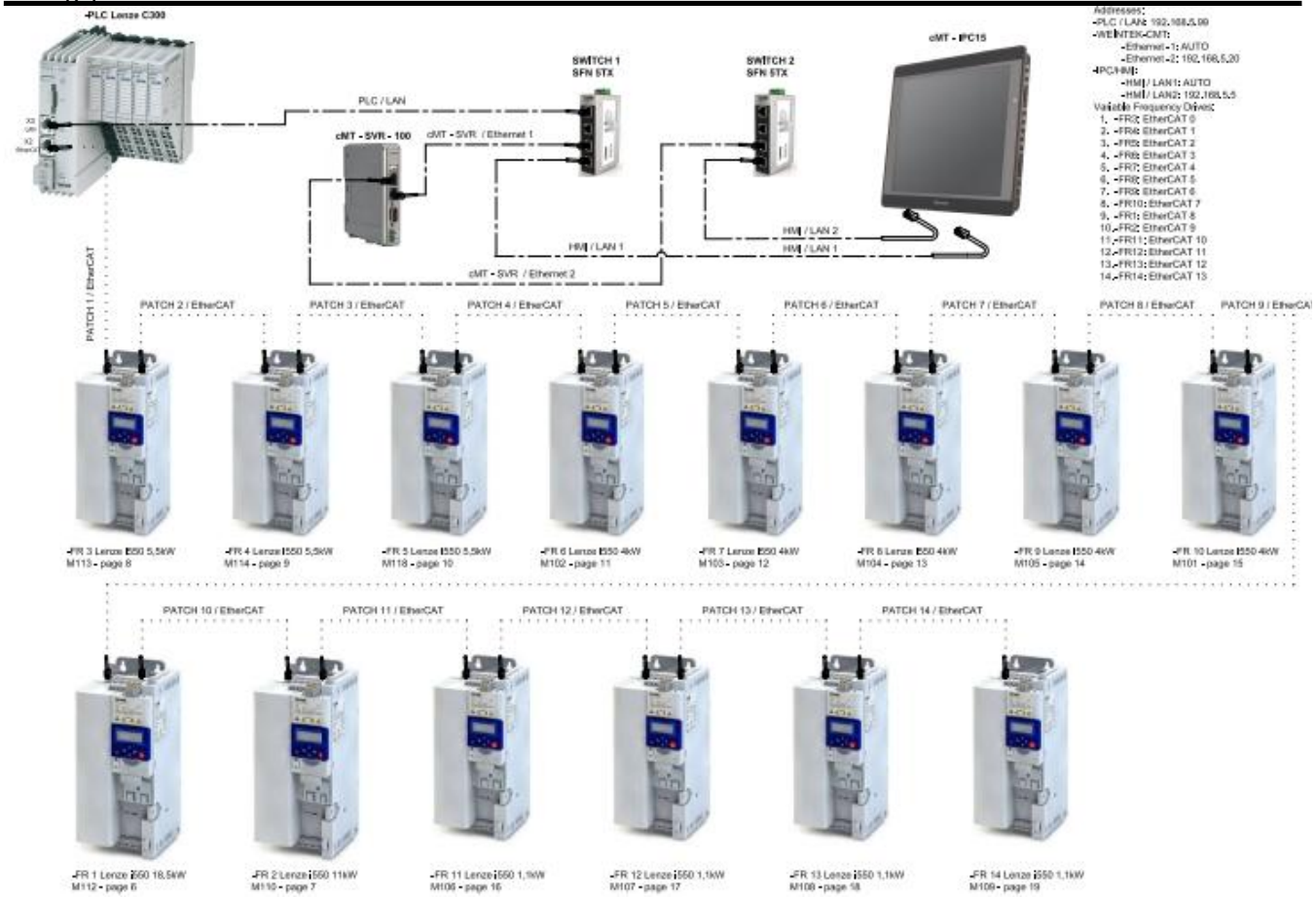
In this system, we can recognize three networks:

1. Ether cat – independent communication protocol between frequency drives and PLC (port X1 at PLC)
2. LAN ethernet – Independent communication protocol between PLC, CMT SVR and IPC and this communication protocol goes over SWITCH inside the cabinet marked as (LAN)
3. Internet – this communication provides web access both for CMT SVR device and IPC. It goes over network Switch marked as INTERNET.

Ethercat network enables fast way of communication between PLC and frequency drive. All elements are connected in series, and all motor values and commands are driven over this network. Each frequency drive has two ports for incoming communication jack and outgoing communication jack. Be assured that all communication cables are properly connected and secured.

DANGER

- Unstable communication or communication loss disables frequency drives



Picture No. 9 Network topology

LAN network communication is a ground level of communication in this system. All data important for normal operation are transmitted over this network. PLC has a function to process control algorithm, but over this network all data from PLC Is represented at control application. All commands over phone app or application at display are transmitted and processed over this way of communication.

WARNING

- Communication loos will not stop the process (it will continue to work as it's set up), but it wouldn't be possible to monitor process via any of the apps (at phone or IPC)

Internet network provides web access for mobile phone application and remote desktop application. In LVCP cabinet separate switch is installed only for this type of communication, so physical layer is separated from other communication layers. All settings, both for CMT-SVR device and IPC are set to default – automatic IP address configuration, so there is no need for IP address adjustment, in order to get this app online and remotely accessible.

WARNING

- Do not mix or switch cables for different communication methods (otherwise none of them will work, because of device settings)

ADVICE

- If there is a need to rearrange or check cables, be assured that each cable is put on its original place, according to wiring diagram
- If there is no internet, please check main router or reset it. Do not pull out cables from switch without a good reason

5.PROCESS DESCRIPTION

Biomass boiler plant is run on wooden chips as a fuel. Wooden chips is stored in storage, outside the container. Storage has built in moving floor, driven by hydraulic aggregate No.1. by two hydraulic cylinders moving back and forward, when dozing sends a request for fuel. Material is then transported over screw conveyers M 101 and M102 up to the dozing basket where fliss is stored in short period of time, just before insertion to combustion chamber. Dozing basket, on its top side has sliding door, as a security, prevention of fire to go back up to the storage. Moving slider is automatically closed when M102 is not working. Detection is done with two inductive sensors, which detect slider position. If slider is not in open position, M102, and M101 and M110 will not start. Level of dozed fliss is measured with two ultrasonic measuring devices (marked as L1 and L2) located at front side of the basket. Measuring range of this devices is from 300 up to 1200 mm. According to settings in software application this level regulates dosing call for storage to start and transport conveyer M101 and M102. If any of motors stops in this line of control, the supply line will stop to, this is also a main condition for start procedure, but in reverse process. Setting for dosing basked are done at display. At dosing basket upper and lower limit are crucial for fuel feeding in to dozing basket. Feeding of fuel from dosing basket up to a combustion chamber is done by M103 motor, which is controlled by feeding algorithm, according to a desired temperature and measured temperature of hot water at boiler output. (At this dozing screw conveyer, various methods of back fire protections are installed, but more about this will be described in chapter protecting functions).

When fuel is feed into combustion chamber, two moving grates will evenly distribute the fuel into combustion chamber during the time and during the thermal phases of combustion. Combustion itself is tightly related with amount of oxygen inside the combustion chamber, that is achieved with two fans, primary (blowing air from the lower side, up trough the grid), and secondary fan which is blowing air directly into a combustion chamber. During the process of adding oxygen into a combustion chamber difference of atmospheric and chamber pressure is constantly monitored and controlled. This difference of pressure has to be very low, from 25 up to 70 Pa, and that is achieved and regulated by exhaust fan, which controls this value and keeps it at desired setpoint. Setpoint of pressure difference varies on temperature inside the burning chamber, and that will be described in settings chapter.

Temperature in combustion chamber is monitored at two separate points, and value of temperature inside can go up to 1000 degrees Celsius, in order to keep that heat inside the boiler, make an efficient thermal use and prolong work life of components and materials, some most of the parts at boiler plant are water cooled. Combustion chamber itself has a double water-cooled wall, cooled with main circulation boiler pump. Grates inside the combustion chamber are also water cooled, and thee two pumps work all the time to provide efficient and safe use of the boiler plant. After the combustion ash and slag are pulled out (time laps is defined by algorithm in software according to heat production itself) with ash M104 and slag M106 conveyers. This product of combustions is transported in to a storage bins for slag and ash.

Hot air as a product of combustion heats up water in boiler and over heat exchanger inside the boiler transfers heat to a water which is over the main pump fed to a primary side of mainboiler plant heat exchanger. Secondary side of this heat exchanger is a consumer side, so their water inside the boiler plant is isolated from consumer water. At this point, supply and return side of heat exchanger, heat production is measured by installed water flow device and two temperatures at supply and return side. This value of heat becomes later important in controlling the process of combustion.

During the combustion most of the products, like ash and slag are transferred and stored outside the boiler plant, but small particles are still present in the air. To achieve high standards, and keep environment from pollution, a multicyclone with filter is installed between boiler and exhaust fan. It serves to collect small particles and transfer them to a storage bin. As most of the particles will stay inside the multicyclone, stuck on its walls, a vibrating motor is installed at the bottom of the multicyclone device. All these products are transferred over the rotational dozer and ash conveyers to a storage bin. This process is done periodically, as defined in user software settings. Current state of multicyclone (is it clean or not) is monitored by sensor for differential pressure.

Amount of oxygen, as very important part of combustion, and output parameter, is measured by oxygen sensors at two main points. Fist one is at the output of the combustion chamber, and second one as at boiler output at

exhaust air. Safety limits are defined for this value, at user interface software and it is a blocking parameter for some fuel feeding and primary and secondary fans.

Quantity of air (fresh air and return air) is measured at 2 points. After primary and secondary fan, and at the exhaust fan. Quantity of fresh and mixing air is defined by software algorithm. Mixing of hot and fresh air is done at 3 positions, at outlet of hot air before exhaust fan (by regulating damper DA1 and before secondary fan by 2 independent dampers DA2 and DA3 (for fresh air and hot air). Mixing is calculated by amount of oxygen in combustion chamber and temperature inside combustion chamber.

Protective functions

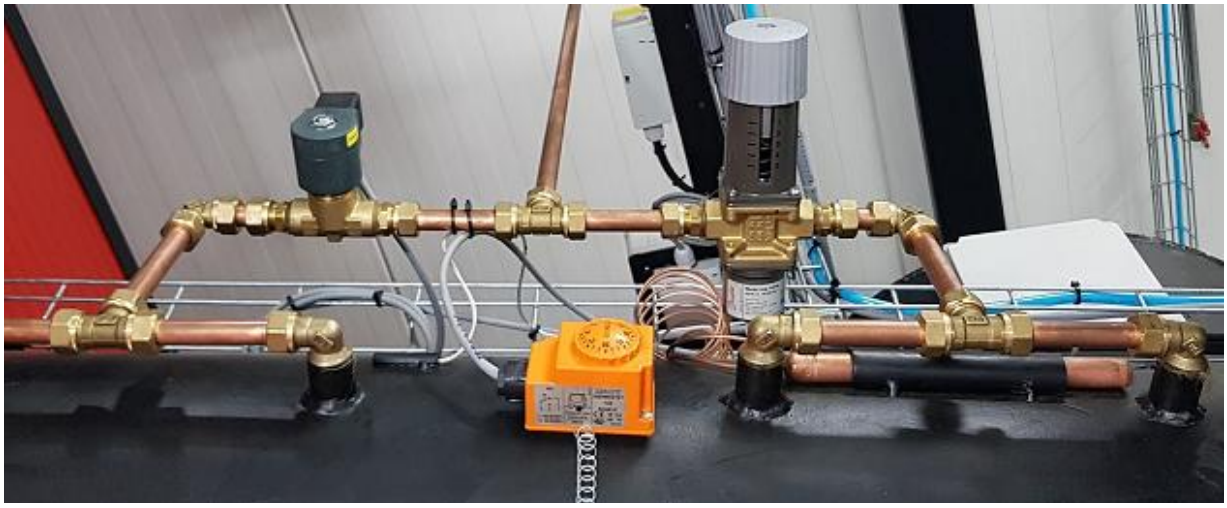
Protective functions are engineered at two stages

1. Controller and mains power independent
2. Protective function by power supplied devices (PLC, frequency drive etc.)

Mains power independent protective functions

Boiler plant has high safety demands, so most important parameters of the boiler are kept in a safe range even in situations where there is a power cut of (lack of mains power supply). These functions keep pressure and temperature in a safety range, and this is done by following methods an equipment:

1. Pressure range is kept in safety range by safety valves, where in case of high boiler pressure, safety valves are turned on and excessive water is pressured out of the boiler plant
2. Back fire protection, at fuel feeding is done by safety thermostat installed at the screw conveyer M103. In case of excessive temperature fire protection valve is opened and water from a safety tank is flushed down to aconveyer



Picture No.10 Fire protection set

3. Back fire protection is done also by two measured values of temperature (power independent by redundant power supply).
    a. Analog value of temperature measured by PT-1000 probe at the surface of M103 conveyer (if setpoint value is exceeded fire valve will open.
    b. Digital signal from thermostat at eh surface of the conveyer M103 will also open the valve. Setpoint is given at head of the thermostat itself.

Picture No.11. Safety thermostat

DANGER

- Improper settings of safety thermostat can cause fire, damage, injuries and death

Protective function by power supplied devices (PLC, frequency drive etc.)

Most of the protective functions is done by power supplied equipment and some of the protection functions are directly at the device and some of them are calculated and processed by PLC itself.

Direct protective functions

Direct protective functions are supplied with protective or starting device itself. By that mean we have two categories

- Protective switches
- Safety relays
- Safety functions by starting and regulating equipment

Protective switches and safety relays

All electrically power equipment is protected according to EN regulations. All protective switches, starting from main switch up to the motor protection switches have thermal, short circuit and overload protection set according to protection level and device. Settings of these values is done directly at protection switches. Main circuit breaker has 3 states. Off, on and trip position (goes to this state when some protection function is activated)

Picture No.12 Main circuit breaker No.

Cabinet has installed earth leakage relay, so any current leakage will be detected and main power will be cut of by tripping the main circuit breaker.

Picture No.13. Earth leakage relay protection set

In case of overvoltage, overvoltage protection will be activated. In this case alarm at application software will occur, and overvoltage cartage should be replaced as soon as possible. System will work normally, but this protection will be inactive if cartage is not replaced.

Picture No.13 Overvoltage protection

Motor protection switches are installed and set according to protected device. Each frequency drive ad soft starter has its own protective device, and each direct motor with direct start has its own protection switch. Motor protection switch has two states, Of and On, and if not tripped by some protective measure, it can be turned off manually. Each motor at field has one more disconnecting device in case of service. It is mandatory that before each motor service, shut off motor protective switch, secure it and shut of service switch close to the motor.

Picture No.14. Motor protection switches (top row) and fuses

Safety functions by starting and regulating equipment

Each of the motors is drive by frequency drive, soft starter or direct start. Motors with direct start have thermal overload protection relay installed and set, and soft starter has also thermal overload protection installed and set.

Frequency drives

All installed frequency drives are LENZE i550 ether cat version drives, driven by signal from PLC by applied software inside. Frequency drive is equipped with it's own display unit, so all errors and additional information are displayed here.

Picture No.15 Display of the frequency drive

Frequency drive serves to enable soft start/stop and easy speed or torque regulation of connected motor. Frequency drive beside basic protective functions as overcurrent, under/over voltage, safe torque etc. has many inside enabled functions. If protective function is activated please proceed to error handling procedure where frequency drive can:

- detect errors and thus protect inverter and motor from damages,
- detect an operating error of the user,
- output a warning or information if desired

Error types

In the event of an error, the inverter response is determined by the error type defined for the error.
In the following, the different error types are described.
Error type "No response" The error is completely ignored (does not affect the running process).
Error type "Warning" A warning does not severely affect the process and may be also ignored in consideration of safety aspects.
Error type "Fault" The motor is brought to a standstill with the quick stop ramp.

- The inverter will only be disabled after the quick stop is executed (motor at standstill) or after the time-out time set
- Exception In case of a serious fault, the inverter is disabled immediately. The motor becomes torque less (coasts).

Error type "Trouble" Just like "Fault", but the error state will be left automatically if the error condition is not active anymore

- Exception In case of a severe trouble, the inverter is disabled immediately. The motor becomes torque less (coasts).
- The restart behaviour after trouble can be configured

For more detail about frequency drive error handling precure, safety and start up please download and use: http://download.lenze.com/TD/i550%20Cabinet%200.25-132kW%20(Firmware%2005%2003%2000%2000)__v12-0__EN.pdf

PLC protective functions

Software in Programable Logic Controller - PLC – is defined fro controlling this biomass boiler plant, and it can't be used in any other purpose than this. Among many other parameters, safety limits and alarms are defined inside the plc. Some limits are fixed (for safety reasons) inside the PLC, and some values are free to be programmed inside the operational range. Be advised that safety limits can make significant impact on functionality and safety of this boiler plan. Do not allow any untrained personnel to change or adjust safety parameters. Alarms are activated and displayed according to pre-set values. Each alarm defines some action at the Biomass Boiler plan.

All alarms can be divided into 3 groups

- Boiler - process alarms
- Variable frequency drive alarms
- Warnings

Boiler process alarms

- AlarmLowPressure
- AlarmLowExhaustTemp
- Alarm_Water_Overheat1
- Alarm_Water_Overheat2
- Alarm_Water_Overheat3
- Alarm_Furnace_Temp1
- Alarm_Furnace_Temp2
- Alarm_Screw (makes alarm for each of the screws)
- Alarm_HYD1_Oil_Level
- Alarm_HYD2_Oil_Level
- O2 alarm 1
- O2 alarm 2

Variable frequency drive alarms

- Variable frequency drive Error (makes alarm for each of the drive)

Warnings

- Motor protection switch (for each of the motor respectively)

All alarm and warnings are enabled over push up notification for a mobile phone and SMS or emergency call to a predefined numbers.

6 USER APPLICATION SOFTWARE

User application software ca be accessed over the mobile phone app, or CMT Viewer app at installed IPC. Remote access is also enabled, over team viewer, any desktop or supremo. In any of application user interface is the same, with absolutely same functionality.

Navigation trough pages

Navigation is done by simple toolbar, where all pages can be accessed easily. Navigation bar consists of 5 fields, where each of the field leads you to a predefined page. Navigation tool bar is located at top page of the window.

Picture No.16. navigation bar at user application software

At bottom of the page alarm bar is located, and if any alarms are active, they will be displayed at this part of the screen in a form of scrolling text of the alarm.

Picture No.17. Alarm bar with scrolling text of active alarms

Main page

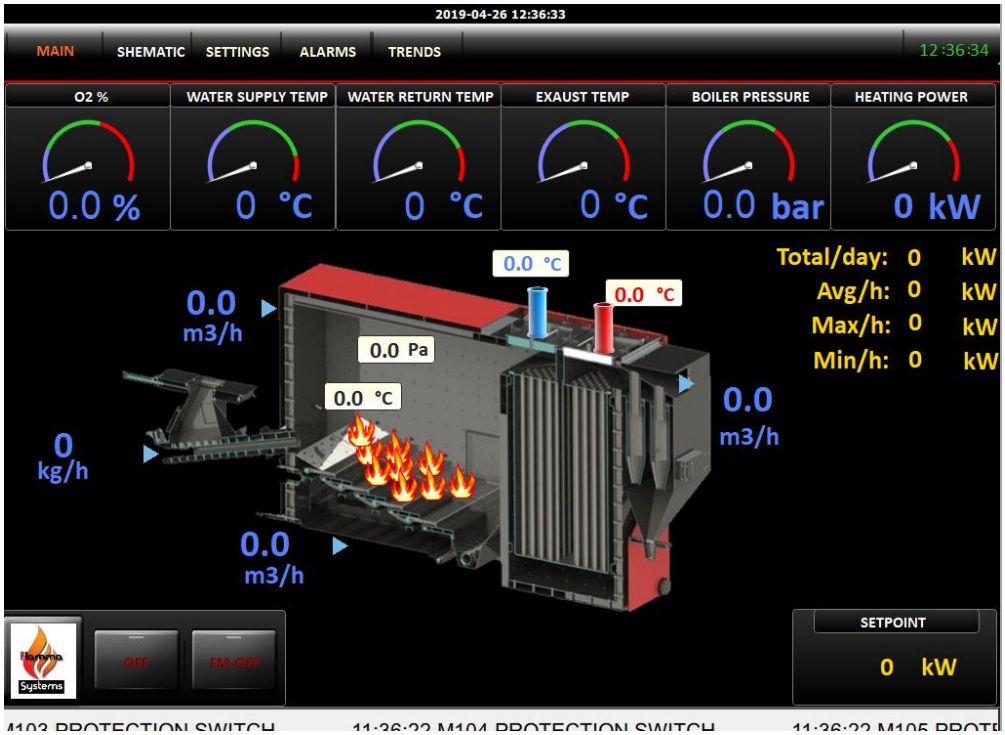
At start up, main page will appear. Purpose of main page is to display basic information about system and to give user a place to have a quick preview of monitored values, start or stop the biomass boiler plant.

At top row preview of following values is set

1. Value of Oxygen after the combustion chamber
2. Water supply temperature
3. Water return temperature
4. Exhaust temperature
5. Boiler pressure
6. Heating power

Some statistics is also done in software algorithm, so it is displayed for user to have a quick preview of heating power

1. Total production during one day in kW
2. Average hourly production in kW
3. Maximum peak of production in kW
4. Minimum of daily production in kW



Picture No.17. Main page of Biomass Boiler Plan application software

At central part of the display there is a graphic preview of combustion chamber and boiler itself together with a fuel feeding transporter. Air quantity at each measured section is displayed together with fuel quantity per hour for main

fuel feeder. Supply and return temperature are show at top of the boiler, coloured with blue (as return temperature) and red (supply temp from boiler).

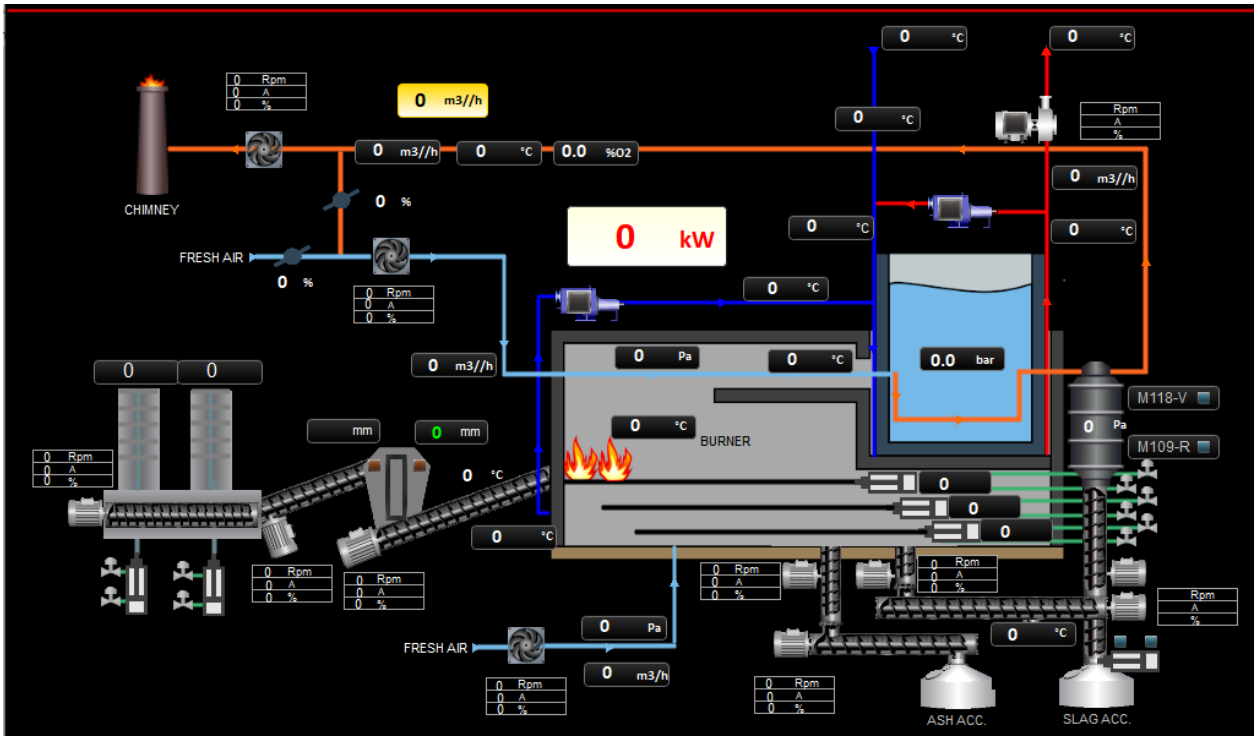
Start / stop of the boiler is done completely automatically, simply by pressing the ON / Off button at the left edge of the screen. Procedure for automatic start or stop will be handled according to a software algorithm. If there is a need to maintain fire for some time, FM button will to the job for you. If pressed FM-ON, boiler will set up parameters for minimum production, just to maintenance the fire inside the chamber and be ready to get of from FM (or we may call it a sleep mode). FM mode can also be activated automatically if temperature in buffer tank reaches its setpoint.

To generate desired amount of heating energy per hour, you must enter the desired setpoint at the right corner of the main screen. Set up range is from 700 kW up to 1.5 MW of heating power averagely per hour. System will calculate amount of fuel needed to have such amount of energy, and it will set up dozing according to needs of end user.

Schematic page

At this page whole process is displayed at simplified Process and Instrumentation diagram. Status of all motors is displayed as followed:

- If colour of the motor is grey – motor Is OFF
- Ic colour of the motor is green – Motor is ON
- If colour of the motor is Yellow – Motor is working in reverse mode of rotation
- If colour of the motor is Red – motor is in alarm



Picture No.18. Schematic view of process

Beside each motor simple data is shown

- Current in Amps
- Rpm
- Torque in % (if torque goes over 120% for screw conveyers, rotational direction is applied for 3 sec, and then back to FWD rotation, in order to get unclogged)

Each of the motor or actuator can be drive in manual mode, simply by pressing that motor, actuator or conveyer. In that case a pop-up window will appear as shown on the picture

This picture represents additional settings and preview for each of the motors. Following data are available:

- Top row – Name of the engine
- RPM – current value of RPM - measured value
- Current – Current value of current in Amps – measured value
- Torque – Current value of the torque in % - measured value
- Switch MANUL – Turns ON or OFF manual mode of control
- MAN – Speed in RPM in manual control mode – input data
- MIN – Minimum allowed value of speed – input data
- MAX – Maximum allowed speed – input data
- START/STOP – Starts or stops motor in manual mode – input switch
- FORWARD/REVERSE – Manual rotation direction selector- input switch
- READY – Drive status
- WARNING – There is a warning at frequency drive
- ERROR – there is an error at frequency drive
- MPS – Motor protection switch active

Picture No.19. Manual motor control plate

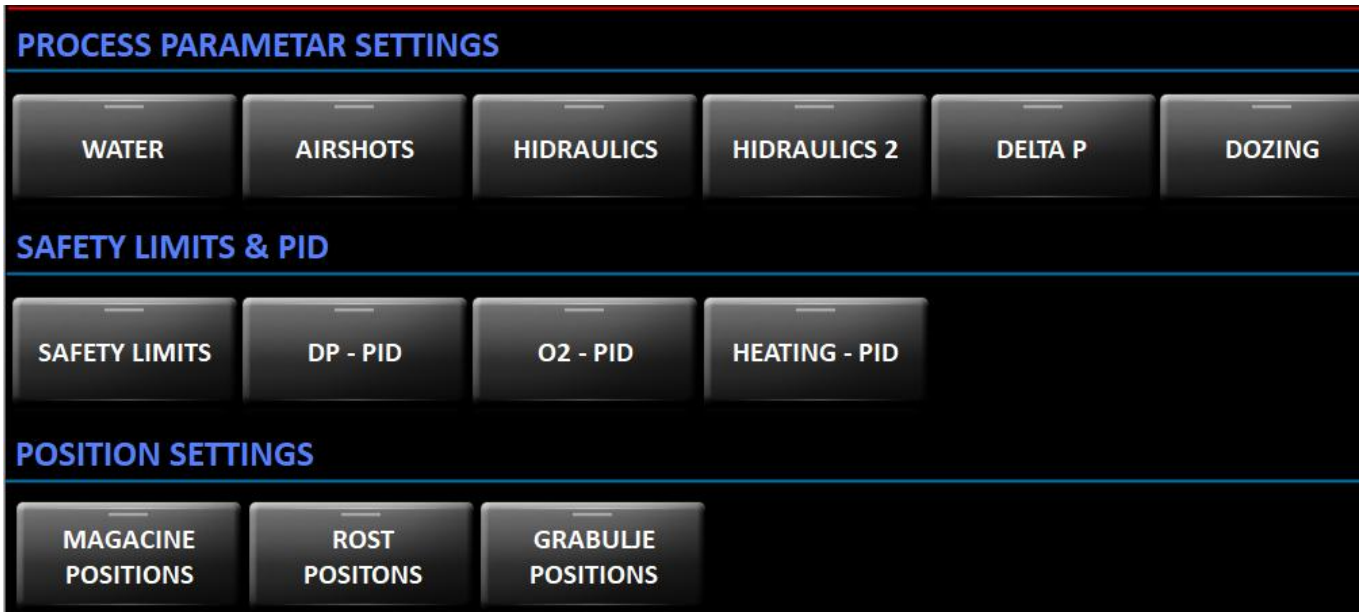
IMPORTANT

- Each STOP or START of the Boiler plant, at main page, switches all motors to automatic mode
- If manual mode is active during run, it will stay like it until stop of the boiler plant
- Do not leave unattended pop up

Settings page

By simply pressing the settings page at navigation bar, it will lead to you to parameter settings page. At this page there are 3 groups of parameters

- Process parameter settings
- Safety limits and PID loops settings
- Position settings



Picture No.20 Settings page

Process parameter settings

Here you can adjust parameters which are, important for process control, such as

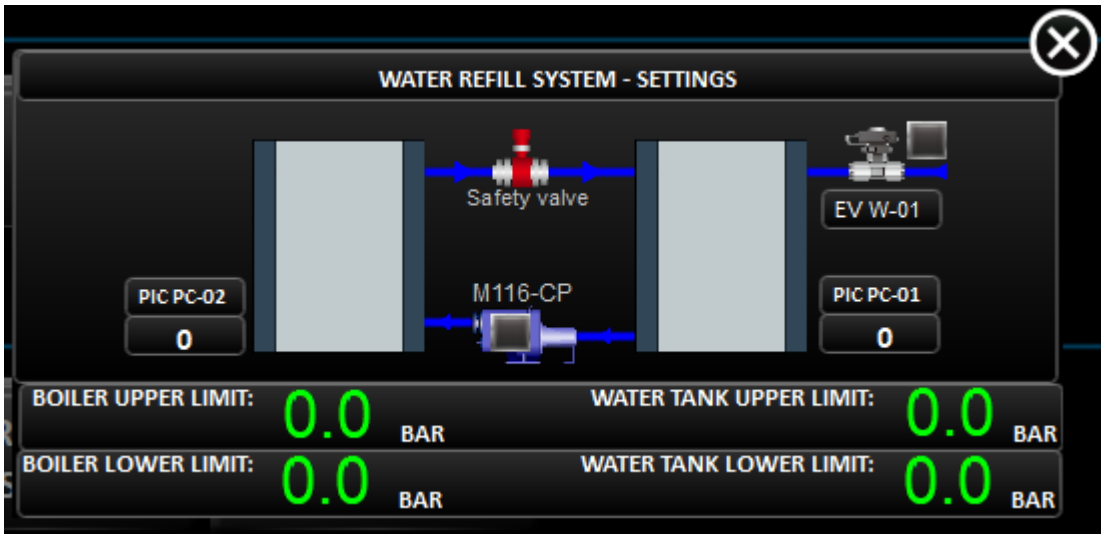
- Water
- Airshots
- HIdraulics at storage
- Hydraulics at combustion
- Delta P – Pressure in combustion chamber
- Dozing settings

Water

At this place are located settings which are related with water pressure in boiler and water refill system. System consist of one pressure sensor, located at boiler, which gives user a current value of water pressure inside the boiler, water tank for storage the excessive amount of water or water for supplying the boiler al together with one supply pump, two valves and level monitoring device inside the water refill vessel. Water refill vessel has two functions

1. To have prepared water inside the vessel, and pump it to a boiler if pressure is below lower limit
2. To receive excessive amount of water from boiler, if pressure is above Upper limit

Upper and lower limits of boiler pressure are adjustable by user, and they control safety valve (active when there is a high pressure in boiler) and supply pump, which pumps the water from the vessel to a boiler, if pressure is low. When level in vessel is low water refill valve will be activated until desired water level is reach at vessel.



Picture No.21 Water refill system settings

Airshots

Air shots are electrically driven valves, which pump air under high pressure inside the tubes of the boiler, in order to keep them clean. There are 6 air shot valves in total, and they are activated one by one, in certain period of time, with a break time between cycles. All settings for this feature are available at screen Air shots.

Picture No.22 Air shot settings

Hydraulics – Storage / Moving grates

Pressing the link hydraulics, pop up will appear for hydraulic system for moving floors in storage. The pop up is the same as for the other motors, with same data as show on Picture No.19, but at this pop up we also monitor oil level and oil temperature. These are limited conditions for this motor to run, if temperature is high or oil level is low, motor will be unable to start.

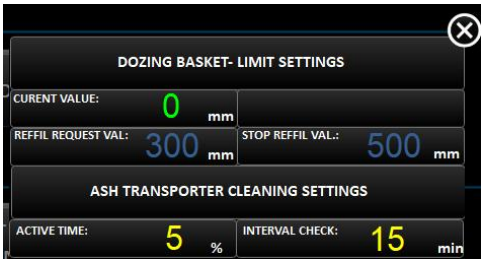
Delta P

This feature keeps the combustion chamber under atmospheric pressure and it serves as a setpoint for exhaust fan. Value of pressure which will act as a setpoint depends directly from a temperature in exhaust air. Here it's possible for user to adjust sliding diagram for this value according to a measure temperature at exhaust air.

Picture No. 23 Burning chamber pressure settings

Dozing – Basket settings

At this place, user can define, how much fuel will be stored in dozing basket, and when it will give a call for fuel from storage. User defines level of fuel in dozing basket. If fuel level is bellow minimum, it will give a call for fuel, if a fuel level is above upper limit, it will stop the fuel transport from storage to a dozing basket. According to the fuel that goes into the combustion chamber, actually according to a working time of dozing conveyer M103, it is possible to define when (by adjusting an interval) and how much (by adjusting a percentage) will ash and slag conveyers work. Percentage is actually percentage of working time of dozing screw M103.



Picture No.24 Dozing basket settings

Safety limits & PID settings

Safety limits play important role in process regulation. So here you can adjust when will alarm appear and at which limit will react in system.

- Exhaust low temperature – sets the limit of low temperature in exhaust air
- Low O2 – detects low level of O2 and starts a procedure according to an algorithm
- Low Pressure – Detects low pressure in combustion chamber
- Water Overheat – Upper limit for water over heat (two other lower limits are set -3 degrees from this value)
- Boiler High pressure – monitors and alarms high water pressure in boiler
- Hydro 1 Hi temp – limit for high temperature of hydro aggregate 1 for storage
- Hydro 2 Hi temp – limit for high temperature of hydro aggregate 2 for moving grates
- Hydro 1 Hi pressure – limit for high pressure of hydro aggregate 1 for storage
- Hydro 2 Hi pressure – limit for high pressure of hydro aggregate 2 for moving grates
- Feeding high temperature – Activates fire prevention valve at M103

Picture No.25. Safety limits

DP loop – PID adjustments of DP loop in combustion chamber

Here, user can adjust PID (proportional, Integration and Differential) values of PID controller, for maintaining the pressure in combustion chamber.

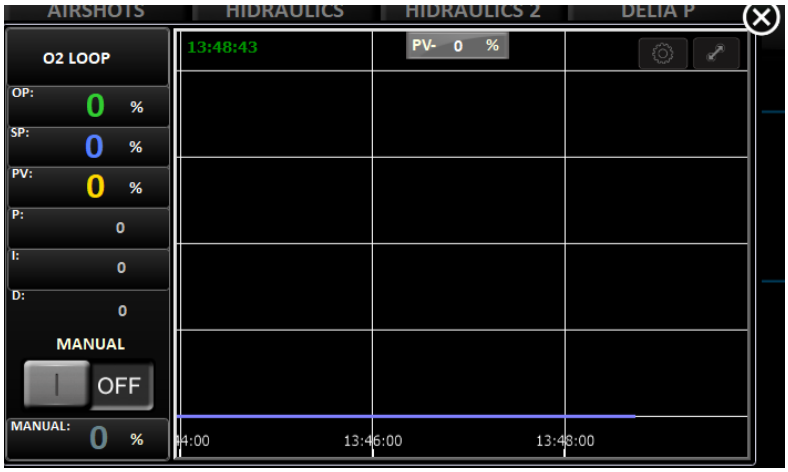
These values can be overwritten in manual mode, simply by written OP (Operation value) to an OP Manual field. Exhaust fan is running according to these values. These values can be monitored in real time in show diagram. DP stands for difference between atmospheric and combustion chamber pressure.

Picture No.26 DP loop settings

O2 loop – PID adjustments for maintaining the desired O2 value at exhaust air

Here, user can adjust PID (proportional, Integration and Differential) values of PID controller, for maintaining the O2 value at exhaust air.

These values can be overwritten in manual mode, simply by written OP (Operation value) to an OP Manual field. Secondary fan is running according to these values. These values can be monitored in real time in show diagram. Keeping the O2 value in proper range, provides good combustion of Biomass boiler plant

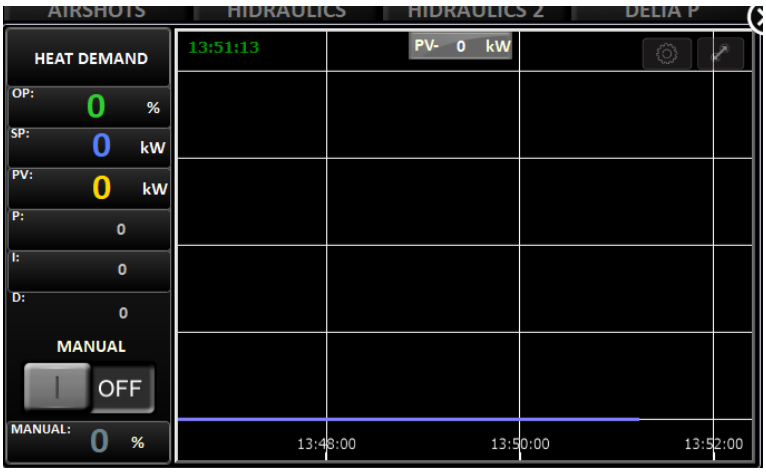


Picture No.27. O2 loop

Heat demand – PID adjustments for maintaining the desired heating power

Here, user can adjust PID (proportional, Integration and Differential) values of PID controller, for maintaining the desired heating power set up at start page.

These values can be overwritten in manual mode, simply by written OP (Operation value) to an OP Manual field. Dozing process runs according to these values. These values can be monitored in real time in show diagram.



Picture No.28 Heat demand PID loop

Position settings

This part of settings is related to a position of hydraulic cylinders in storage and combustion chamber

Storage positions

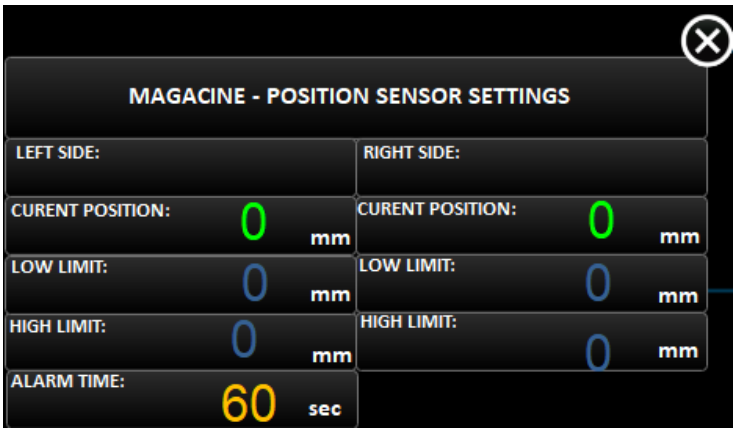
Here user can define following settings for sliding cylinders of moving floor inside the storage which feeds boiler with fuel.

Left side cylinder in storage

- Curent position – displays current position of sliding floor
- Low limit – The lowest point where cylinder changes its direction
- High limit – The highest point where cylinder changes its direction
- Alarm time – If cylinder doesn't reach its highest or lowest limit, it will change direction

Right side of moving floor

- Curent position – displays current position of sliding floor
- Low limit – The lowest point where cylinder changes its direction
- High limit – The highest point where cylinder changes its direction



Picture No.29 Settings of moving floor in storage

Moving grates

Here user can define following settings for sliding cylinders of moving grates inside the combustion chambers. Moving grates distribute fuel evenly during the combustion process.

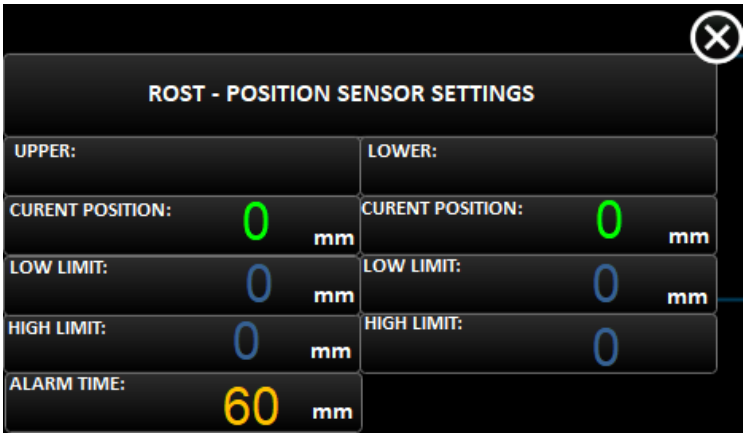
Upper grate

- Curent position – displays current position of upper grate
- Low limit – The lowest point where cylinder changes its direction
- High limit – The highest point where cylinder changes its direction

- Alarm time – If cylinder doesn't reach its highest or lowest limit, it will change direction

Lower grate

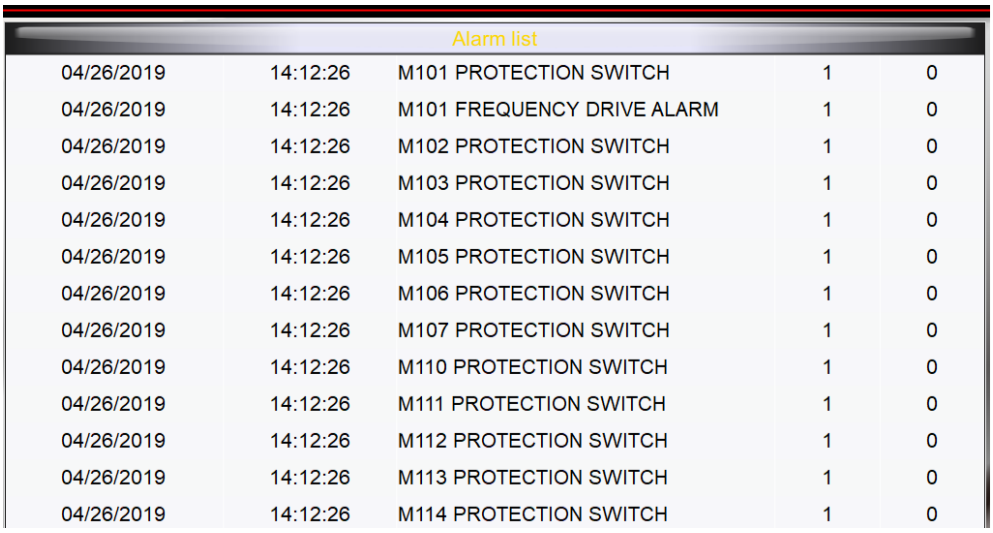
- Curent position – displays current position of lower grate
- Low limit – The lowest point where cylinder changes its direction
- High limit – The highest point where cylinder changes its direction



PIctute No.30 Moving grates settings

Alarm page

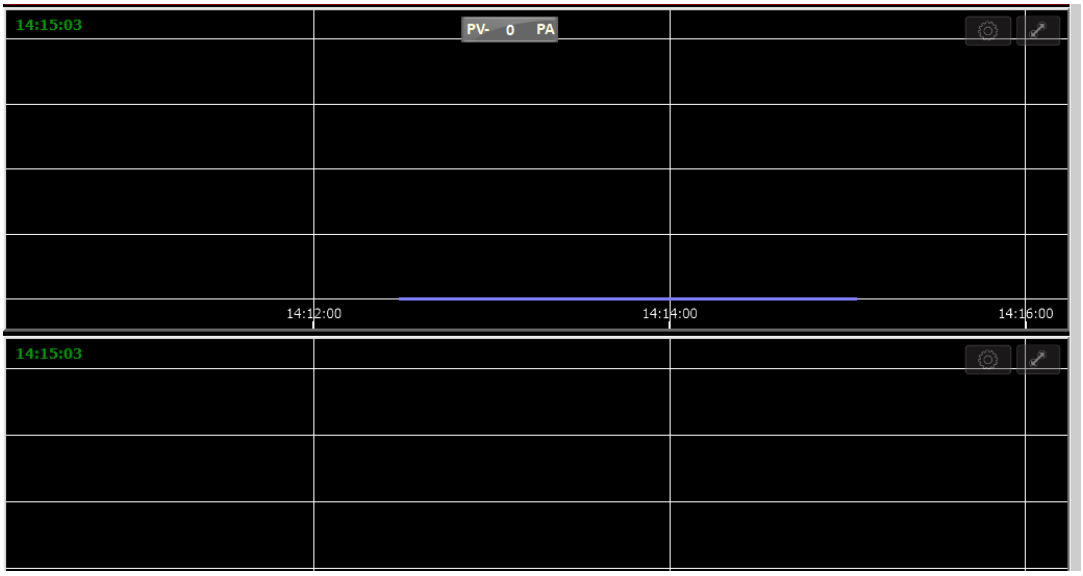
At this page all alarms are displayed, with a short massage of an alarm. This page also keeps in its memory history of all alarms. Active alarm can be acknowledged, but can't be deleted from history.



Picture No.31 Alarm page

Trend page

At this page is possible to monitor historic values of set up trends. So as one of the important values to monitor are DP and supply temperature. At this page you can scroll back and forward and se current and historical values of monitored values.



Picture No.32 Alarm page

7. APPENDIX

- Wiring diagram
- PID diagram
- Lenze I550 ethercat frequency drive manual

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