APPLICATION NOTE

DISTRIBUTED CONTROL SYSTEMS

Janikowskie Zakłady
Sodowe
„Janikosoda" S.A.

System for Control of Cooling Water Circulation

ASKOM

RELIABLE SOLUTIONS OF AUTOMATION SYSTEMS

Doc. No. ENPN011
Version: 04-02-2008

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In August 1999, the investment related to water pollution control of the nearby Pakoskie Lake was put into operation in Janikowskie Zakłady Sodowe "Janikosoda" S.A. The purpose of this investment was to “close” the cooling water circulation within the plant and it required serious modernizations within the production departments as well as building the complex of the pumping units and ventilator coolers to collect the heat from the circulation water. The control system designed for management of the Closed Cooling Water Circulation had to meet the complex functional and location-related requirements of the new technology and its realization was a considerable challenge taking into consideration distribution of the facility, novel measuring techniques used and the very short period of implementation and commissioning as imposed by the Investor.

Design assumptions

The system capacity resulting from the technological projects were determined by the following number of inputs/outputs:

- approx. 210 analogue measurements, including 80 in Profibus PA;
- 223 drives of 0.4 kV pumps and ventilators;
- 9 drives of 6 kV pumps;
- 25 control drives, all in Profibus PA.

All the measurements and controls are concentrated in 7 facilities (fig.1):

- chloride leach system (1),
- saline cleaning system (2),
- P4 switching station (3),
- ventilator coolers (4),
- PW22 pumping station (5),
- PW21 pumping station (6).

The large scale of the system distribution is illustrated by the distances between the extreme processing nodes that exceed 1200 m.

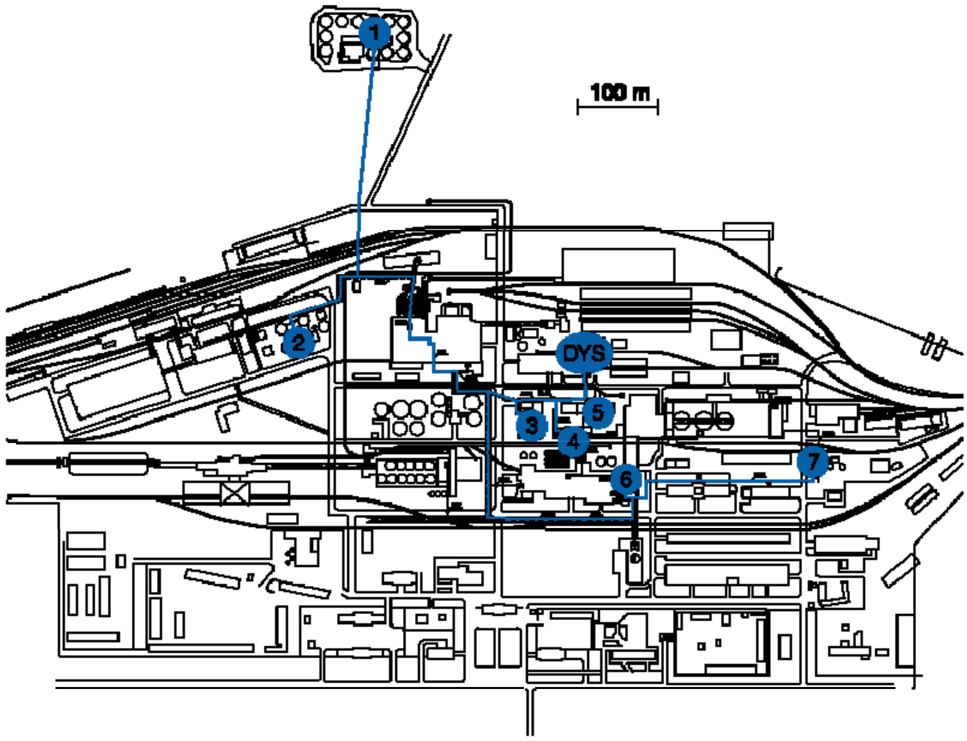

Figure 1. Topography of CCWC control system against a background of the Works.

System structure

The Closed Water Circulation (CCWC) control system was designed in the distributed configuration (fig. 2), with S7-400 controller as the MASTER of Profibus DP network, which, taking into account considerable distances between the individual processing nodes, was based on the fibre optical links. In the CCWC control room, from where the operators supervise the installation operation, the control cabinets were located and the following was installed in them:

- S7-400 controller,
- 2 operation servers,
- supervisory PC station (KE),
- data server, which transfers process data to the site network.

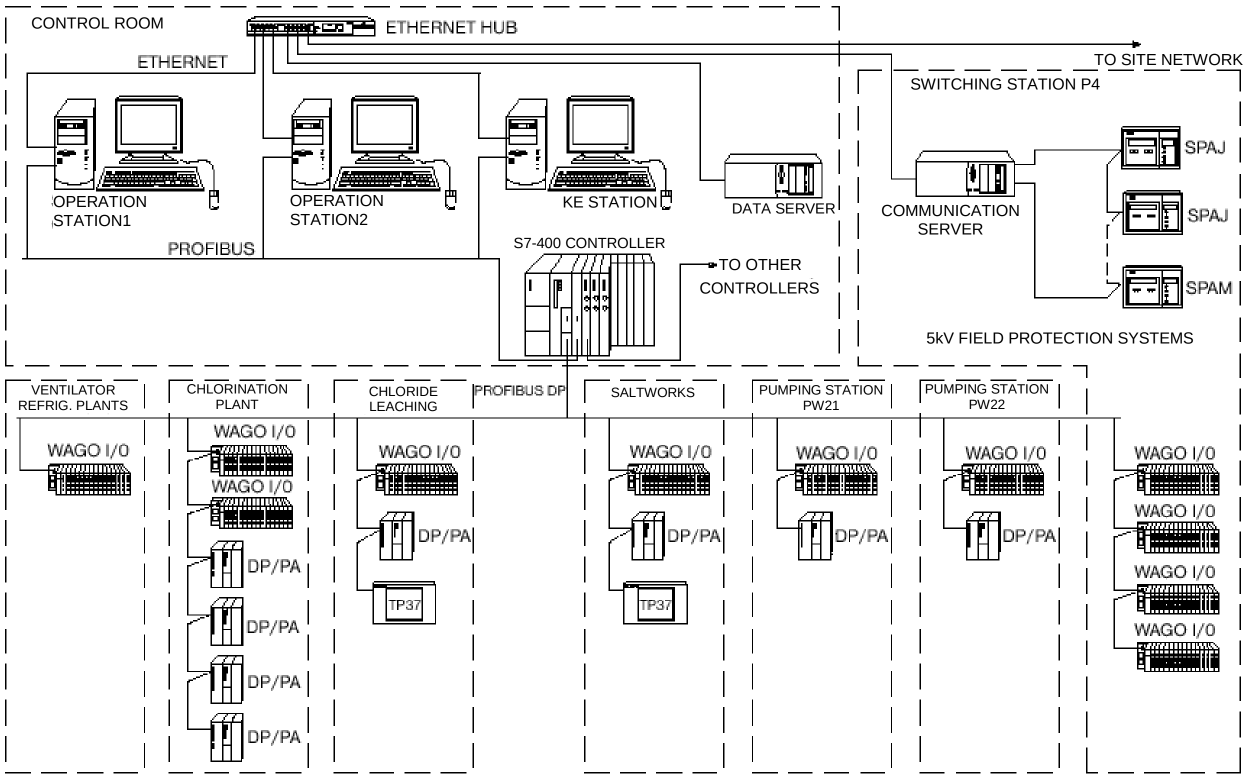

Figure 2. CCWC control system structure.

The personnel in charge of the system operation have at their disposal the operation servers with the installed **asix** visualisation system, which operate in the hot reserve mode, and the operation supervisory station. The hot reserve mode operation ensures full redundancy of servers and coherence of archives and alarm logs. Apart from the situations when it is used by the maintenance personnel, the supervisory station is also used as the auxiliary monitoring station. Fig. 3 presents the mask illustrating the PW30 pumping station and the related ventilator refrigerating plant.

For every process facility the control cubicle (or cabinet for smaller systems) was designed and made and in this cubicle the fibre optical distribution frames, Profibus DP network nodes and power supply systems were installed.

The Profibus DP nodes consist of the WAGO I/O System components and the DP/PA link systems to provide connection with smart measuring transducers and actuators equipped with Profibus PA digital interface. WAGO I/O is the system of 2- or 4-channel input/output modules, grouped to form the plant network node (in this case Profibus DP). Simple configuration, wide range of modules and "tailormaking" along with the possibility of easy extension has decided that WAGO was selected as the supplier of peripherals. Almost every temperature measurement is carried out by Pt100 sensors and their results are transferred directly to the WAGO elements with RTD inputs.

The Profibus PA standard, adopted during the design of analogue measurements and controls, has brilliantly simplified and accelerated the instrumentation assembly. One 2-wire line has connected "serially" the group of approx. 20 transducers with the control cubicle. The use of intelligent transducers and positioners shortened the system start-up and its adjusting to the required operating conditions.

Every cubicle (equally with the central system) was equipped with the 24 V DC control voltage uninterruptible support system. The applied solution ensures the ability to monitor the facility status and control the pneumatic controllers even when the power supply is broken completely. The system supply stabilisation efficiency was proven at the times of power failures at the Works.

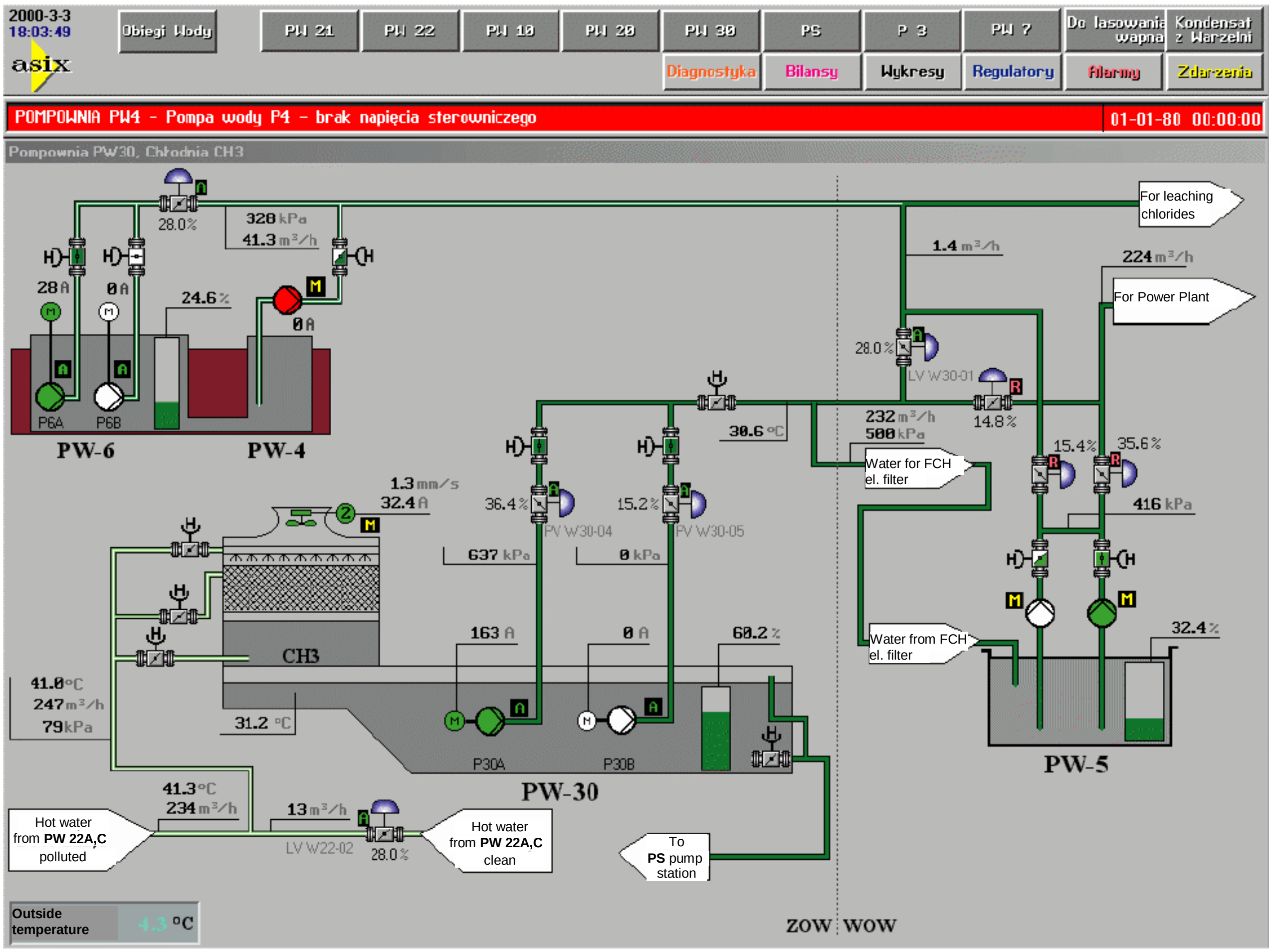

Figure 3. PW30 pumping station mask.

Control of 0.4kV and 6kV drives

The control and supervision of the medium-voltage drives, powered from the ABB-ZWAR fields, was realised on two ways. The switching on and off commands and the basic information on the drive status are transferred over two-state signals via the WAGO I/O elements, whereas the PC-concentrator gathers information from the microprocessor protective relays and transfers it to the operation layer via the serial links based on the ABB's SPA protocol. To this end, the 6kV switching station fields were equipped with 20 SPA-ZC communication modules from ABB to connect with the data concentrator via fibre optical network. The concentrator was configured in the plant network as the **asix** server with a specialised driver for the I/O modules.

This allows recording the reasons for emergency shutdowns of the 6 kV pumps and also viewing the values and changing the parameters of the protection systems remotely as well as displaying the history of shutdowns for the P4 switching station from the nearest **asix** terminal. The control of 0.4 kV drives was designed by classical means, using the WAGO I/O elements and separating out the independent potential group for each drive.

The system also switches over automatically the pumps operating onto the shared collector, at the same time assuring the pressure stabilisation in the collector. The objective of this procedure is to ensure the even wear of the pumps and drives. The time dependences between the operations of the cut-off dampers and switching the pump on and off were selected empirically so that when observing the pressure trend it is difficult to notice the moment when the switchover takes place.

Control loops

The CCWC control system comprises about 35 control loops. The 3 main groups of parameters are subject to stabilisation. These are:

- circulation water pressure,
- temperature of water downstream of the coolers,
- water level in the pumping stations.

The temperature of water downstream of the coolers is regulated by changing the efficiency of ventilators driven by two-speed motors. As the temperature of water reaching the cooler cannot exceed the admissible level, the system automatically reverses a part of the cooled water onto the entry, when necessary, so that it is mixed with hot water. The control algorithms are calculated in the controller by standard SIEMENS's Modular PID Control software. The transparency of the software, which is assembled as if it was built “out of the LEGO blocks”, facilitates further extension of the system to include the additional functionalities and regulators. The control loops are tuned from the visualisation system level where the automation engineer has access to the settings and the effects of his actions can be observed on the dedicated, short-term trends.

Using PROFIBUS PA standard features

Profibus PA (Profibus for Process Automation) is a developed in 1996 standard for the measuring and control devices, which allows data to be entered as well as parameterised and read out from multiple devices connected to the same 2-wire line.

The consistence with Profibus DP protocol ensures the ability to transfer data bidirectionally between the transducer and the controller, using the existing, rich infrastructure of the Profibus DP network.

During the design of the system the opportunities provided by the new measurement standard were taken into consideration. The operation control PC was connected to the Profibus DP network and thus, using Commuwin software by Endress Hauser, the automation personnel were given remote access to the transducers and positioners. Commuwin software allows the status of the measuring devices to be parameterised and diagnosed on-line, without interruption to their operation. Both the controller's and the visualisation system's software uses functions that are specific to Profibus PA. From the flowmeters, for example, not only the momentary value but also the counters are read out. It is possible to display the measurement system structure on the screen where the PA transducer (positioner) status will be colour-coded. Every measurement is expanded to include statuses returned by the transducers (see fig. 4) and all the failures and events are recorded and stored in the alarm log.

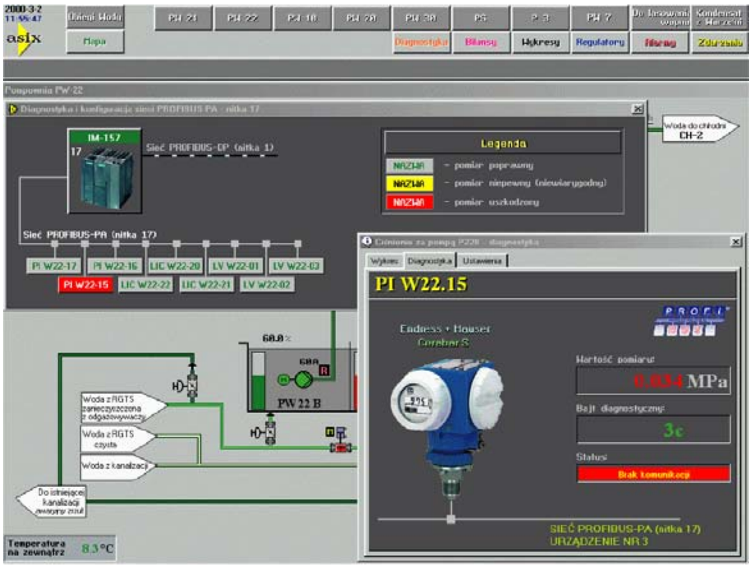

Figure 4. Technological mask with PROFIBUS PA measurement window.

Integration of control systems

The Closed Cooled Water Circulation control system was integrated with existing process systems as well as those that are just being designed. The information on water flows, pressures and temperatures gathered by other controllers that were operated before as stand-alone are transferred to the CCWC control system over the separate Profibus network. The integration of departmental control systems was realised both in the process layer (direct data exchange between controllers) and in the operation layer. The control and supervisory systems of the following facilities were incorporated into the Works site network (see fig. 5. Control and supervision systems at Janikowskie Zakłady Sodowe):

- CCWC system (approx. 2800 variables);
- K4 boiler (approx. 1300 variables),
- K5 boiler (approx. 1700 variables),
- cooling system for gas from RHCD distillation (approx. 1300 variables),
- carbonisation system (approx. 1300 variables),
- fodder additives system (approx. 1000 variables),
- lime-kilns department (approx. 300 variables),
- sodium bicarbonate whirling system (approx. 1600 variables).

This year, the above summary will be expanded to include the K21 boiler control system.

To ensure safe communication between the servers that operate in the hot reserve mode, the connection with the network is provided via the hub that separates traffic within the site network from the local network segment of the operating PCs. The separate PC data server was only assigned to the CCWC control system to ensure fast remote access to the CCW process data (2800 variables).

At present, more than 11 800 process variables (excluding the alarms), including the analysis results entered manually by the laboratory assistants, are transferred to the PCs operating within the Works site network. The full integration of the operating systems (current and archive values, alarms and events) was possible thanks to the homogeneity of the installed visualisation software. The **asix** visualisation system is currently operated on 18 servers and more than 30 remote terminals. The synthetic visualisation, which concerns, among other things, the balance of water flows (see fig. 6), is functioning on the terminals and in the future the visualisation of the balance of heat flow among individual departments will be also possible. At this point, the industrial process visualisation system gets into the enterprise management layer, supporting the account of costs on the inter-department settlements level.

We are not able to specify the exact number of operating terminals, as Janikowskie Zakłady Sodowe purchased the "site licence" for indefinite number of stations.

ASKOM designed, made and started the CCWC control system within 4 months.

The range of the works included:

- design and execution of networks, including the fibre optical networks,
- design and execution of the communication system with protection systems for 6kV drives,
- design and prefabrications of control cubicles,
- deliveries of controllers with Profibus network components and PCs with the visualisation system installed,
- software engineering for PLC's and PCs,
- system start-up.

The existing cooling water circulation was switched over to the "closed" one during the 4-day downtime in the plant. Before it was started again the whole system was ready for being controlled from the CCWC control room.

The user-friendly graphic interface of the visualisation system and the intuitive menu system allow the whole system to be run by one operator. It also creates favourable conditions for comfortable operation by the personnel. The data from the installation are available in the site network, thus allowing the automatic generation of reports and balances and supervision of the personnel's work.

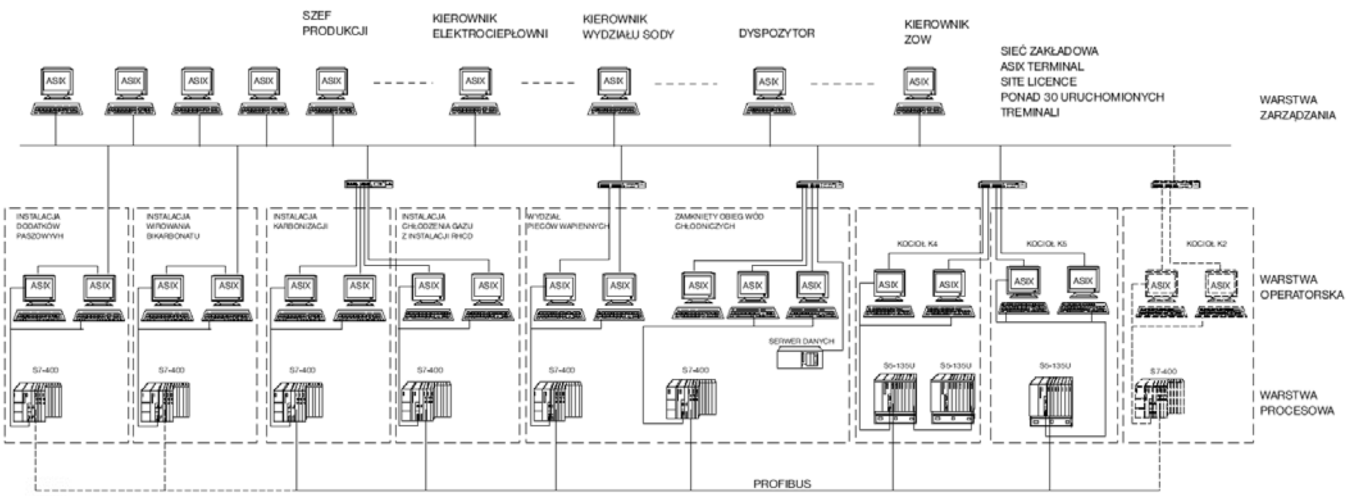

Figure 5. Control and supervision systems at Janikowskie Zakłady Sodowe.

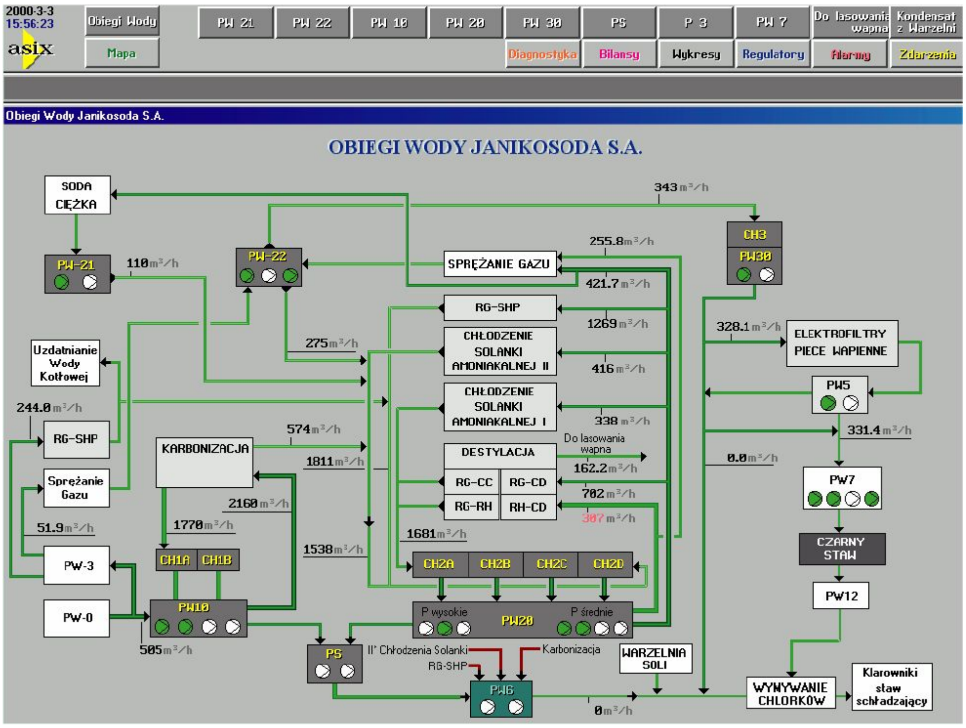

Figure 6. Water balances mask.