Rehabilitation of Wastewater Treatment Plant Gardabani

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Abstract - **In this project, the problem was the realization of a SCADA (Supervisory Control and Data Acquisition) system and automation system that will reduce the costs of maintenance, will increase energy efficiency and will help to improve the quality of wastewater that drains into the river and which comes directly from the sewerage system of Tbilisi and Gardabani cities. The automated station will work non-stop, with high efficiency in water quality and cleaning. The warranty of this station is 25 years without mechanical defects, from which comes the decrease on the maintenance expenses towards a non-automated station.**

Cuvinte cheie: *Sisteme SCADA, stație de epurare, PLC, HMI, software, hardware, licență, ecrane automatizare, rețea de comunicare.*

Keywords: *SCADA systems, wastewater treatment plant, PLC, HMI, software, hardware, license, screens, automation, communication network.*

I. INTRODUCTION

The trend in wastewater treatment is toward more diversified and complex processes. This also leads to the need for a consistent operation, where automation is becoming increasingly important [1]…[3]. This project includes:

- Identification of each object and description of destination and function. Its automation and competence are in accordance with the specification.
- Making communication between hardware and building a single network
- Making graphical user interfaces for SCADA system and established control condition.
- Creation and implementation of SCADA system were conducted at the company's request „STRABAG" Bucuresti, Romania, in collaboration with „Salonix" Chisinau, Moldova.

Application of automation in wastewater treatment operation has two primary functions: data acquisition and process control. For the former function, the level of automation is relatively high. The thousands of variables, which are gathered on-line in the SCADA systems of treatment plants, and data analysis are standard components of the treatment operation and quality monitoring. There are several indications that the situation is changing and that the treatment industry is experiencing a transition towards a higher level of automation for both information acquisition and process control. The importance of process automation at municipal wastewater treatment plants (WWTPs) has increased as treatment requirements have tightened and the processes have therefore become more complicated. Since the implementation of the European Directive 91/271/CEE regarding urban wastewater treatment, environmental water protection has gained increasing public awareness among European Union Countries. The treatment requirements for the WWTPs are determined together with national legislation based on the implementation of the European Directives, depending on the sensitivity of the receiving water body in terms of eutrophication, especially for nitrogen removal requirements.

The necessity of cost-efficient and reliable treatment processes has considerably increased in order to meet the continuously more stringent level of environmental regulations and, on a larger scale, to achieve the challenging national targets for nutrient load reduction into water bodies. As a result of these regulations, major upgrading and new construction works have taken place, in particular for more efficient nutrient removal. Implementing more advanced Instrumentation, Control and Automation (ICA) system represents the right way of renovating a WWTP, leading to the more optimal use of the unit processes [8]…[10]. Moreover, on-line measurements and controls based on them are essential in the flexible and cost-effective operation of modern nutrient removal plants.

II. GENERAL DESCRIPTION OF THE CHAMBERS

Gardabani WWTP is receiving waste water at the inlet chamber through five inlet pipelines:
Main Collector 1: Tbilisi, Rustavi, Gardabani 1 Concrete Pipeline Dia. 3,300 mm.Main Collector 2: Nitrogen Concrete Pipeline Dia. 1,200 mm.Industrial 1: Power Plant Steel Pipeline Dia. 245 mm.Industrial 2: Power Plant Steel Pipeline Dia. 245 mm.Collector: Gardabani 2 Steel Pipeline Dia. 325 mm. Block scheme of the wastewater treatment plant is shown in Fig. 1

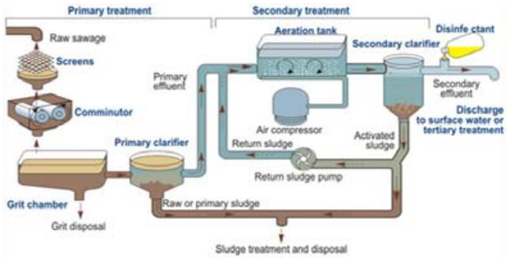

Fig. 1. Block scheme of the wastewater treatment plant.

A. *Distribution Chamber*

The plant inflow is distributed towards the current eight (8) screen channels. The incoming wastewater enters to the wastewater treatment plant at the Inlet Chamber.

In front of inlet chamber a new shaft will be built. This shaft will be constructed around existing inlet concrete pipe DN 3300 mm as well as steel pipe DN 1200, while both pipes are still in operation. The new shaft will also be connected to four smaller inlet pipes and to a new temporary bypass (DN 2200 mm) for bypassing screens plants and grit chambers.

B. *Screening*

In the screening hall eight (8) bar screens are available, each in a single screen channel, with approx. 20 mm gap width serves to screen the waste water. Screenings are discharged on a conveyor belt and subsequently in containers and then disposed of. The fine screens, conveyors, screenings press and containers are enclosed in the building. Five channels are used for the installation of fine screen with automatic mechanical operation. Three screen channels will be used for bypass the screening plant. The screen building is equipped with a hoisting system.

The building for the fine screens, conveyors, press with their screening containers ensure operation in freezing conditions. Fan heaters are provided and ensure 10 °C in the building when the weather is cold for a proper operating process.

The building is equipped with additional ventilation fans. The ventilators are controlled by local room thermostat.

A gas leakage detector is a necessary installment in this building. In this case entering the screen building is not allowed. The daily amount of screenings in the fine screens is calculated with 10 l/(PE x a) and 358,000 inhabitants. The daily screenings quantity is calculated to approx. 10 m^3/d of wet screenings. For the dimensioning of the transport system the peak flow is chosen to 4 m^3/h. After pressing the screenings, the quantity will be approx. 5 m^3/d. Electrical works of the screens of the wastewater treatment plant are shown in Fig. 2.

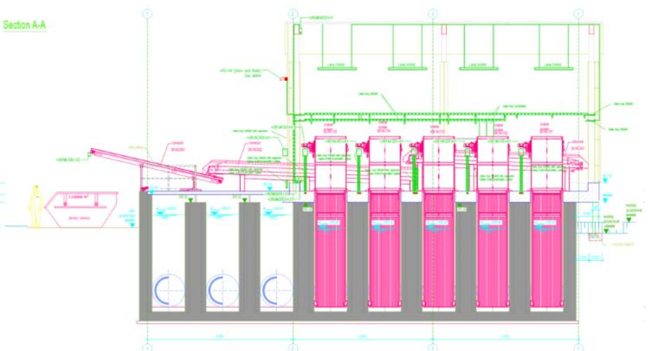

Fig. 2. Electrical works of the screens of the wastewater treatment plant.

The roof of the admission building is designed to dismantle the metallic construction above the coarse screens to allow the transport of each screen outside the building in case a replacement will be necessary in the future. The SCADA screen of the the screens of the wastewater treatment plant are shown in Fig. 3.

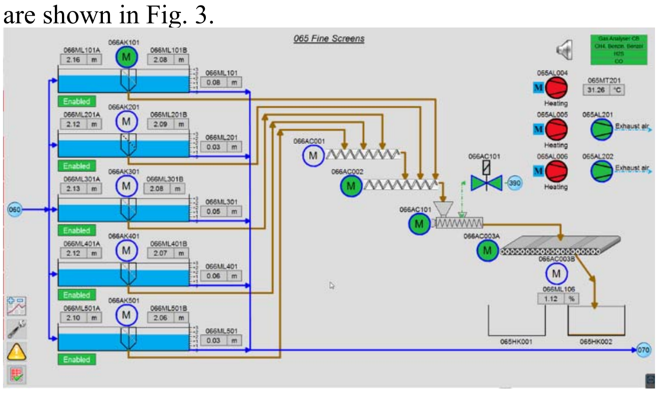

Fig. 3. Screens of the wastewater treatment plant.

The water level upstream and downstream the coarse screen is measured by level measurements (061ML101 - 105). A predefined water level difference (approx. 10 cm) starts the cleaning operation of one screen (set point 061/11). The screenings fall into the skip of the belt conveyor. Screens and conveyors are interlocked and work synchronously. The conveyors start operation shortly before the screens start. When the screens stop a pre-selected time sequence (30 seconds) later, the conveyors stop, too. Above the screenings containers a level measurement (061ML106) will be installed. The level sensor measures the filling level of the container and allows the change of discharge point for coarse screenings.

C. *Grit Chambers*

The aerated grit chamber and grease trap are the first stage of the biological process, following the principles of an adsorption-activated-sludge-process (AB-process). The grit removal and the high loaded aeration tank are one unit. The combined function is biological treatment and sand plus grease removal.

Four grit and grease removal tanks will be constructed, each capable of handling 25% of the maximum flow under rainy conditions. Hydraulically even higher flows can be treated, but efficiency will decrease.

Grit will be removed in order to reduce the risk of damage to the mechanical equipment in the following treatment units, and grease will be removed to avoid non-aesthetic conditions caused by the volatile organics and malodorous floating sludge. The settled grit will be transported to the grit classifier then unloaded into a container. The retained grease will be scraped off and discharged into a grease collector shaft. Electrical works of the grit chambers of the wastewater treatment plant are shown in Fig. 4.

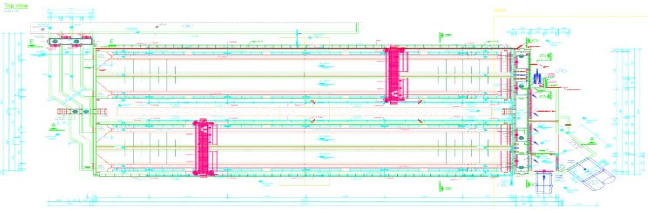

Fig. 4. Electrical works of the grit chambers of the wastewater treatment plant .

Normal operation 070:

- The sensor (070ML001) measures the water level in the distribution chamber at inlet side;
- The sensor (070ML002) measures the water level in the distribution chamber at outlet side;
- The sensors (070MQ101 - 201) measure the oxygen concentration in the outlet channel of the combined aerated grit and grease removal chamber and high loaded aeration tank;
- The sensor (070ML101) measures the water level in the pump sump for feeding grit classifier;
- The sensor (070ML102) measures the water level in the pump sump, protects against pump dry running and sump overflow;
- The sensor (070MF001) measures the flow towards grit classifier.

The SCADA screen of the grit chambers of the wastewater treatment plant are shown in Fig. 5.

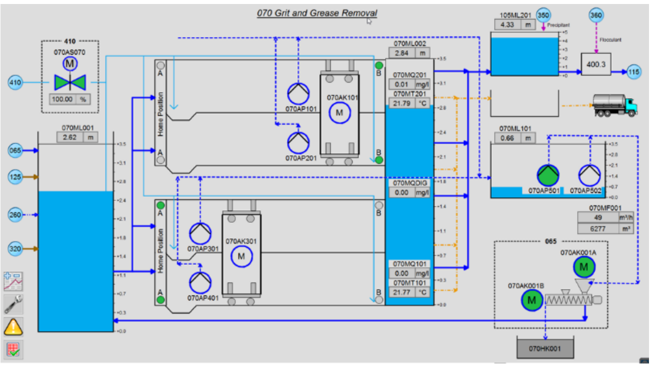

Fig. 5. Grit chambers of the wastewater treatment plant .

Two tanks are fitted with a common scraper bridge. The scraper bridge removes sand and scum. The scraper bridge starts running from the park position at the influent side of the tank in direction to the outlet. Two submersible grit slurry pumps are installed at one bridge. During the movement to the end sand is pumped to a grit collecting channel, one channel per 2 trains. The sand-water-mixture flows by gravity from collecting channel to the common grit collecting pit. The scraper bridge will be interlocked with level in pit with grit transfer pumps. The grit transfer pump will be interlocked with the grit classifier; the start of the pump causes the start of the grit classifier as well. If the pump stops, the classifier keeps in operation for a predefined time sequence. When reaching the end position of the tank the scum blade forms in a trough at the end of the tank and the scum will be evacuated towards the collecting pit. After a pre-selected period, the scraper changes his moving direction towards inlet. The sand pump is still working until the scraper bridge reaches the parking position at the inlet side of the tank. The scum blade will be lifted up and kept in the uplifted position while the scraper is running back to the inlet of the tank. The scraper bridge operates cyclic time-controlled by package unit control cabinet. After a predefined time, sequence (4 hours), the scraper starts running for a predefined amount of cycles. The scrapers are interlocked to each other because of capacity of grit classifier.

D. Distribution Wells

Currently two (2) distribution chambers are used to hydraulically distribute the pretreated wastewater to the primary clarifiers through weirs, equipped with shut-off gates.

E. Precipitation Station

The ferric chloride dosing plant is a stand-alone plant which starts with a signal from the treatment works control system. The ferric chloride dosing plant has the ability to accept a signal to pace the dosing pumps in response to flow, through the WWTP Outlet channel. Storage tank for the ferric chloride is located indoors, frost free and is isolated in a separate frame to protect from accidental leakage. The ferric chloride is dosed into the two outlet shafts of the grit chambers (object 070) to the distribution chambers of the primary sedimentation tanks in proportion to their respective waste water flow rate.

Two possible operating modes are foreseen:

- The precipitation flow rate is calculated in proportion to the discharge flow in the outlet channel (object 200). In case of rain weather (Qoutlet > 19,858 m^3/h) the proportional dosing rate shall be limited (Set point 350/11). Dosing rate is controlled to be proportional to the outlet flow measured by the flow sensor (200MF001) in object 200;
- If requested by process conditions or during maintenance the precipitation dosing rate can be adjusted manually independently from WWTP outlet flow (Set point 350/12).

F. Flocculant Station

The polymer preparation system is designed as an automatic preparation plant for polymer powder. The storage for the polymer powder is designed for a 10-day functioning. The polymer solution shall be dosed into the distribution wells of the primary sedimentation tanks in proportion to their respective wastewater flow rate. The flocculant station is equipped with four dosing pumps. Two redundant dosing pumps are provided for each of their dosing lines. Electrical works of the flocculant station of the wastewater treatment plant is shown in Fig. 6.

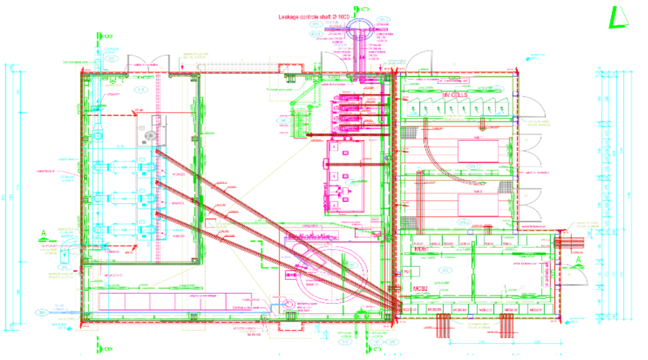

Fig. 6. Electrical works of the flocculant station of the wastewater treatment plant.

Two possible operating modes are foreseen:

- The polymer flow rate is calculated in proportion to the discharge flow in the outlet channel (object 200). Dosing rate is controlled to be proportional to the outlet flow measured by the flow sensor (200MF001) (Set point 360/11);
- If requested by process conditions or during maintenance the precipitation dosing rate can be adjusted manually independently from WWTP outlet flow (Set point 360/12, Set point 360/13).

The SCADA screen of the flocculant station of the wastewater treatment plant is shown in Fig. 7.

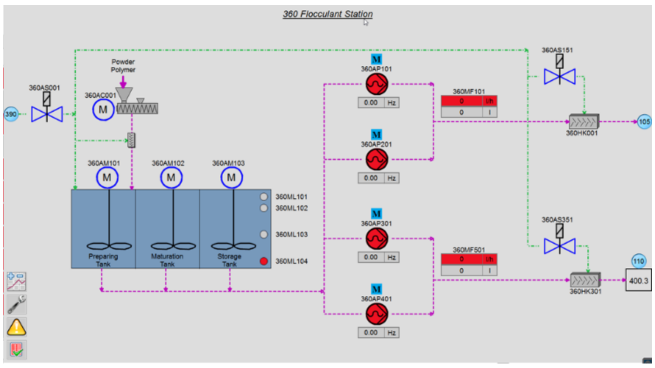

Fig. 7. Flocculant station of the wastewater treatment plant.

Normal operation of the flocculant station:

- The sensors (360ML001-360ML004) measure the polymer level;
- The sensors (360MT101-360MT401) measure the pump temperature;
- The sensors (360MP101-360MP401) measure the pressure at the pump stator;
- The sensors (360MF101 and 360MF501) measure the flow;
- The control of dosing will be done automatically or manual.

G. Primary Clarification

There are ten (10) round shaped primary clarification basins in the plant of which five (5) units are currently in operation. The diameter of the units is 50 m. The primary clarifiers remove readily settleable solids and floating materials and reduce the suspended solids content. The purpose of the primary clarifiers is to remove a substantial portion of the organic solids from the untreated wastewater, with a resulting decrease in the organic and solid loadings in effluent channel.

Treated wastewater will be discharged into outlet channel. The settled sludge on one hand will be pumped to the aerated unit chamber to activate a biological treatment process and to increase the efficiency of the mechanical treatment stage. On the other hand, primary sludge will be pumped to the static thickener. Electrical works of the primary clarification of the wastewater treatment plant is shown in Fig. 8.

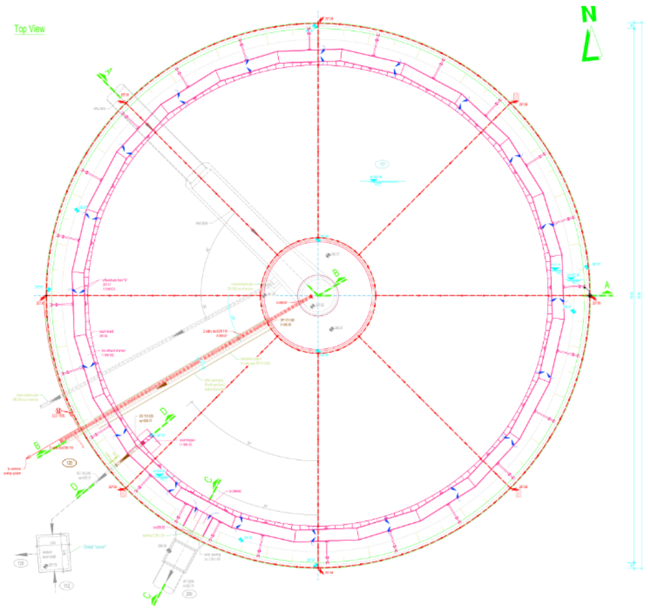

Fig. 8. Electrical works of the primary clarification of the wastewater treatment plant.

Normal operation of the primary clarification:

- PST 1, 2, 3 and 4 are fed with the flow coming from the distribution well PST (object 105);
- PST 5 is fed with the flow coming from shaft no. 3 (object 400.3);
- The sensors (110ML101, 110ML201, 110ML301, 110ML401, 110ML501) measure the sludge levels;
- The scrapers (111AK101, 112AK201, 113AK301, 114AK401, 115AK501) are working continuously.

The SCADA screen of the primary clarification of the wastewater treatment plant is shown in Fig. 9.

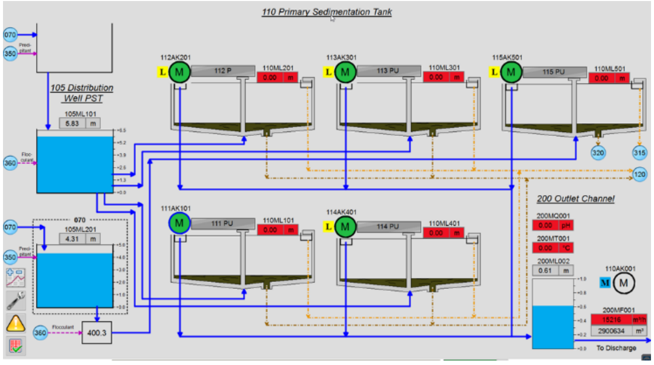

Fig. 9. Primary clarification of the wastewater treatment plant.

H. Outlet Channel

The clarified waste water is discharged into the outlet channel. The water then enters the WWTP's original bypass channel and subsequently the runoff channel of the plant.

I. Sludge Machinery Station

The pressured air for aerobic sludge stabilization and for A-stage is produced in the sludge machinery station. Inside the sludge machinery station three turbo blowers are installed in a separate room. The turbo blowers are designed for 6,500 Nm³/h, each with a pressure difference of 650 mbar. The air demand is calculated for a fine bubble aeration system in the stabilization tank. The blower capacities are adequate to keep the minimum oxygen concentration in the stabilization tanks at 0.5 mg/l minimum. The blower units aerating the sludge stabilization stage are monitored through pressure, temperature and flow sensors and registered in the Process Control System (PCS).

J. Primary Pumping Stations

Raw sludge from the primary clarifiers is pumped through 2 (two) raw sludge pumping station towards the sludge drying beds. Electrical works of the primary pumping stations of the wastewater treatment plant is shown in Fig. 10.

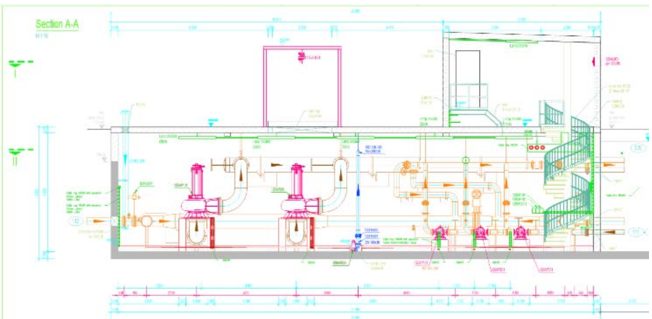

Fig. 10. Electrical works of the primary pumping stations of the wastewater treatment plant.

Object 125:

The pumping station is operated automatically. The return sludge pumps are controlled by the flow measurement (125MF001). The return sludge flow from the primary sedimentation (unit 111-114) is nearly continuously and flows to the pumping station suction header. The flow sensor will increase or decrease the inverter of the pumps to maintain a predefined flow.

The cycling between the pumps will be done automatically when a pre-selected operation time has elapsed. The operational status of the pumps is monitored by the SCADA system.

For pump start at least one electric valve (120AS101 - 401) must be open.

Object 120:

The primary sludge pumps are operated automatically. A pre-selected daily sludge quantity will be pumped by use of a Start – Pause mode. The primary sludge flow is measured and recorded (120MF101).

The cycling between the pumps will be done automatically when a pre-selected operation time has elapsed. The operational status of the pumps is monitored by the SCADA system.

The sensor (120MP003) measures the pressure in the common scum pipe upstream the primary sludge pump (120AP101). The pump starts operation if a preset value is reached. The gate valves 120HS112 and 120HS212 are usually open. The valve 120HS005 is closed. The scum is discharged towards the sludge thickener object 260.

The SCADA screen of the primary pumping stations of the wastewater treatment plant is shown in Fig. 11.

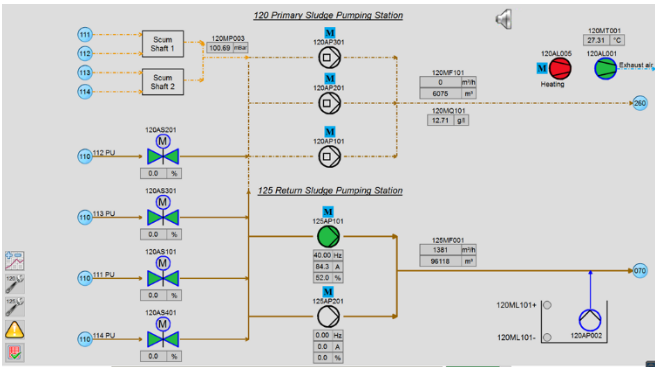

Fig. 11. Primary pumping stations of the wastewater treatment plant.

K. Sludge Drying Beds

Dewatered sludge is loaded to a tractor wagon and disposed of. There are three (3) of ten (10) sludge beds in operation in the plant.

III. SCADA System of the Wastewater Treatment Plant Gardabani

The architecture of the SCADA system consists of four different levels:

1) Field equipment;
2) PLC (Programmable Logic Controller) and RTU (Remote Terminal Unit);
3) Communication networks;

SCADA host computer. The major function of SCADA is for acquiring data from remote devices and providing overall control remotely from a SCADA Host software platform. This provides the management of technological equipment so that these devices turn on and off at the right time, supporting the control strategy and a remote method of capturing data and events (alarms) for monitoring these processes and prevention the breakdowns of technological and auxiliary equipment [4]…[7]. Synoptic window of the wastewater treatment plant Gardabani is shown in Fig. 7.

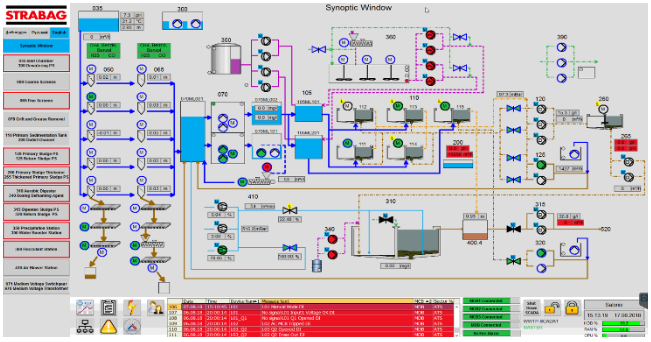

Fig. 12. Synoptic window of the wastewater treatment plant Gardabani.

In the viewing area there is a synoptic window or schemes of separate technological objects, with designations of the direction of incoming and outgoing process flows, which can be called up by pressing a button in the navigation area. Concentration indicators of the LEL (methane - CH_4, benzine, benzol; hydrogen sulphide - H_2S; carbon dioxide – CO_2), in the bottom left part of the viewing area, are highlighted by a conditional color: below LEL - green, above LEL – red. On the bottom of the screen is the information area where is displayed table with information about warnings and alarms of the equipment, low voltage equipment status indicators, user list table. General architecture for the SCADA SYSTEM GARDABANI is shown in Fig. 8.

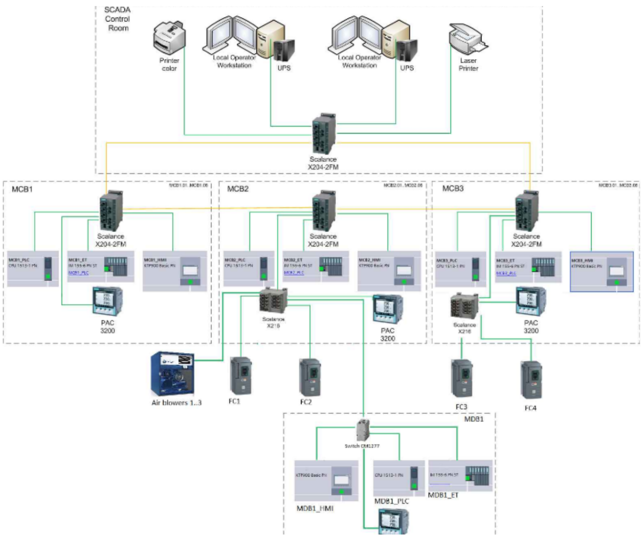

Fig. 13. General architecture for the SCADA SYSTEM GARDABANI.

The structure of the SCADA system, for remote dispatching, gives the service personnel of the station the following possibilities:

- monitoring the condition of equipment at a remote station (parameters of technological process, emergency and work lock conditions);
- to perform remote control of the system, without calling a specialist directly to the remote object;
- monitoring quality indicators of the water purification;
- archiving data (DBMS) on technological progress, keep an event log, view equipment crashes, and view graphs of time-adjusted parameter changes.

Base system and operator interface:

- base system: operator workstation based on an PC with the SCADA system installed;
- operator interface: a set of graphical screens with a mnemonic representation of the treatment facilities structure, light indication and audible alarm [11]…[14]..

IV.CONCLUSIONS

Surveillance of water supply systems is imperative in most European countries for public health services because safe water is an important factor in preventing illness.

1) During the technological processes carried out in the Gardabani treatment plant, it was found that, following the measurements, a negative impact on the environment is presented by the following pollutants: CBO5, ammoniac nitrogen, sulphides and hydrogen supplied, chlorides.

2) Following the monitoring of the station, it was found that these pollutants fall within the limits prescribed by the legislation, having a minor impact on the environment.

3) After the automation, each object in the station works with 20% higher efficiency compared to the old non-automated system.

4) Every second, the data from all the sensors in the station is saved. Based on this data, automated reports are generated by operators at the desired time, with their help, the power station's efficiency and water quality can be seen.

5) After automation of the station for 25 years there will only be expenditures for energy and personnel, that is a 30-40% reduction of expenses compared to the non-automated station.

6) Remote control via SCADA makes the station more flexible to monitor and control.

7) The working precision of all automation equipment has increased by 2 time, this increases their unmanaged operating term.

ACKNOWLEDGMENT

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Contribution of authors:

First author – 60 %

Coauthor – 40 %

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